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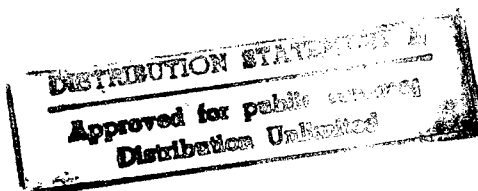
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JPRS Report

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Science & Technology

Japan



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Science & Technology

Japan

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AIST Research Administration Division

[Text]

Importance of Technology Development

By contributing to the advancement of the industrial structure, technology development guarantees the socio-economic development base and creates new places of employment. It also plays an important role in maintaining the free trade system and in making the activation of international trade possible. Recognizing this, Europe and the U.S. are working out government policies for technical development that actively involve the government and private sectors in their entirety. Now, in the so-called "quickenning period" of 21st-century-oriented technological innovation, Japan, too, must exert special policy efforts for promoting creative, independent technical development.

Views on Industrial Technology Policies

MITI's main responsibility is to contribute towards improving the people's way of living through industrial economic growth.

It is thought that the private sector will basically become responsible for realizing the "establishment of a technological state" that is based on creative and independent technology development. Therefore, when working out industrial technology policies, comprehensively and accurately grasping the technology development issues that exist within every industrial field, continuing to make the greatest possible use of the vitality of the private sector, and inducing technological innovation in desirable directions, in single-bodied and all-inclusive cooperation with policies on industry, commerce and trade, and resources and energy, is sought after.

To that end, MITI is striving to provide environmental conditions under which the vitality of the private sector, which is mainly responsible for Japan's technical development, can come into full play. Secondly, MITI is developing industrial technology policies in accordance with the view that the nation itself will promote and encourage those fields that are difficult for the private sector to implement on its own, i.e., 1) fields that have a considerable spillover effect on the industrial economy, or fields that are instrumental to industrial advancement but are very risky, such as those that require a long period of R&D; 2) fields that necessitate establishing systems of cooperation among businesses or among industry, government, and universities, and that require large-scale development investments for the purpose of integrating multifarious elemental technologies, for example; 3) fields where socio-economic needs are great, emergency measures are needed, and development should be accelerated (energy, etc.); 4) fields based on

community needs (medical treatment, public welfare, the environment, safety, etc.).

AIST's Role

(1) Relative Importance in Administration

A. In MITI's industrial, commercial and trade, and resources and energy policy-making and in strategic technology development that is promoted under comprehensive, single-bodied cooperation, MITI's Agency of Industrial Science and Technology (AIST) carries out R&D that is centered on those fields of pioneering and basic technology where large risks are involved and in other such areas where it is fitting for the government to conduct R&D.

B. The results of AIST's efforts have become the substance of industrial property rights and have been utilized in industrial activities. In addition, these results are instrumental in turning up and cultivating the seeds of Next-Generation Industrial Base Technology R&D, which is a national project; large projects; the Sunshine Project; and so forth.

C. When surveying present and future technological innovation, Japan's characteristic weakness in basic and application fields is pointed out. Overcoming this calls for AIST to have a stronger leadership role than it has had in the past, a role that will continue to make the most of its high potential and many years of actual results in the fields it has dealt with. Meeting this kind of demand is the mission of the national research institutes.

D. The national research institutes have been assigned important roles in R&D for the purpose of maintaining the industrial activity environment, e.g., metrology and standards, geological surveys, safety, security, etc. Striving for active promotion in the future is also necessary.

(2) AIST Overview

In accordance with their missions as national research institutes, the sixteen laboratories affiliated with the AIST conduct research that can be useful in improving the technological standards of Japan's mining and manufacturing industries, while maintaining close cooperation with each government administrative organ, other national research institutes, universities, and industry.

These sixteen laboratories consist of nine laboratories for separate specialized fields that are located in Tsukuba Science City, and seven experimental laboratories in each region of Japan.

(Reference)

Personnel: 3,304 people (of which 2,505 are researchers)

Budget: ¥49.4 billion (not including the Coordination Funds for Promoting Science and Technology)

(3) Outline of AIST's Experimental Research

Research carried out at the sixteen AIST-affiliated laboratories is classified as ordinary research, special research, or designated research. The following is a simple explanation of what these kinds of research are.

A) Ordinary research

This is basic-seeds-type research the funds for which are requested by and distributed to the national research institutes on a uniform basis. The per-person budgets for this research are decided upon every year (¥1.460 million per researcher in FY1990). There are about 600 themes; yearly research expenditures for one theme are small, ranging from 100,000's of yen to millions of yen. The total AIST budget for ordinary research is about ¥3.5 billion.

B) Special research

This kind of research builds upon the results obtained from ordinary research and is larger in scale. It is research pertaining to technology that is specifically required in MITI administration or it is basic research that is carried out on a large scale. There are about 147 themes; yearly research expenditures for one theme range from ¥5 million to ¥200 million. The total AIST budget for special research is about ¥2.7 billion.

Special research, which is positioned in the middle between ordinary research and designated research, is objective-oriented research where each project is carried out in a single, consolidated form.

C) Designated research

This is research that is designated as special, priority research at AIST, e.g., large projects, the Sunshine Project, etc. Yearly expenditures for designated research are about ¥6.2 billion.

(4) New Special Research Implemented in FY1991

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Metrology and Standards Technology			
Research on consistency evaluations of ITS-90 normal and middle-range temperatures	The 1990 international temperature scale (ITS-90) defines and adopts several implementation methods such that it will have a high degree of accuracy and users can easily implement it. Consequently, there is a possibility that inconsistencies in temperature values will arise as a result of the different definitions. This research will reveal how consistent the definitions are for temperatures ranging from 0°C to 960°C, and will make the implementation of a temperature standard more accurate.	1. Research on high-precision implementation methods for temperature standards based on ITS-90. (1) Producing an adiabatic-type tin point electric furnace, and investigating its characteristics. Also, the trial manufacture of tin point sealed cells. (2) Producing a hot vessel to use in preliminary experiments for implementing a secondary base point, and carrying out preliminary experiments to investigate the secondary base point's repeatability. (3) Investigating the temperature characteristics of sodium heat pipes.	National Research Laboratory of Metrology
Research related to advances in ultra-clean space measurement	The objectives are to strive for more sophistication in technology for measuring standard particle sizes, micro-wind-speed measurement correction technology, and contamination control technology that uses these technologies—the need for the immediate development of which is indicated in the advances made in the formation and utilization of ultra-clean spaces. In other words, the goals are to develop the high-precision particle-size measurement technology that is needed for determining the sizes of standard particles; to develop practical-use micro-wind-speed correction devices needed in order to establish the tracibility of micro-wind speedometers; and to develop highly efficient measurement control systems that employ these devices.	1. Higher precision in particle-size measurements of standard particles Producing a trial version of measurement equipment that uses dynamical measurement methods to handle the range of small particle sizes and angular-resolution-type optical scattering methods for the range of large particle sizes, and starting precision-evaluation experiments. 2. More advanced micro-wind speed correction methods Preliminary experiments for the purpose of generating low-speed flows that are temporally and spatially stable, and the design of a micro-wind speedometer correction device. 3. By applying statistical methods for the development of integrated measurement control systems in super-clean rooms, the lab will investigate experimental projects for evaluating the errors in standards.	National Research Laboratory of Metrology

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on atomic-beam-method caesium frequency standard equipment	In caesium frequency standard equipment up until now, a Ramsey resonance signal has been obtained by sending out a beam of caesium atoms horizontally and then making it interact with microwaves. There were problems with that method: the speed of the atomic beam cannot be lowered, the beam width of the Ramsey resonance would not become narrower, the amount of secondary Doppler shift would not become smaller, and accuracy would not improve because of the phase shift of the second interaction. An atomic-beam caesium frequency standard is considered as the ultimate method for solving these problems. This research is aimed towards that realization.	1. Research on atomic-beam standard equipment The design of elements such as a microwave resonator, a C-field generator, magnetic shielding, vacuum equipment, etc., and the design of the overall system. 2. Development of a low-speed atomic beam Rigging up a large-output laser, developing its control technology, and confirming reduced-speed efficiency improvements. 3. Investigating microwave control system designs.	National Research Laboratory of Metrology
Research on technology for accurate measurements of biological substances	In protein engineering research that is aimed at the creation of proteins with new functions and in the search for new physio-activation substances (e.g., hormones, vitamins, prostoglandins, interferon, etc.), a tremendous amount of time and labor is needed to separate and purify bio-components that occur in trace quantities and to identify those substances and confirm their structures. This research is aimed at the development of technology for accurately analyzing trace quantities of bio-polymers and measurement technology that will make possible quick and highly-sensitive analyses of mixtures of biological samples by putting separation methods and precision analysis technology on-line.	1. Revamping a tandem quadrupole mass spectrometer and investigating methods for ionizing proteins by means of electro-static spraying. 2. Investigating electro-static spray ionization TOF mass spectrometry methods. 3. Investigating peptide ion decomposition reactions and the possibility of primary structural analyses. 4. Investigating the interfacing of liquid chromatography and mass spectrometry, the objective of which is direct measurements of protein mixtures.	National Chemical Laboratory for Industry
Safety and Security Technology			
Research on measures to counter dust in closed work spaces	In connection with measures against dust in closed work spaces, the establishment of new anti-dust technology that makes the most of new methods (such as real-time dust characterization and flow simulation techniques that employ photon correlation methods, and low-dust construction methods based on new excavation technology) is desired. Through in-lab and on-site experiments and analyses, the aim of this research is to establish basic technology that is related to new techniques for measuring dust in closed work environments, dust behavior predictions based on airflow predictions, and measures against dust generation.	1. Studies on new dust characterization principles such as electro-static principles and photon correlation principles. 2. On-site surveys together with studies on the basic points of difference between outdoor dust diffusion models and closed-space models. 3. On-site surveys together with making a trial version of excavation test equipment and carrying out basic investigations of test methods. Also, investigating preventative-use technology for controlling the size of water droplets. 4. Studies on the contents and images of a database that will be built, the software that will be employed, etc.	National Research Institute for Pollution and Resources

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Resources and Energy Technology			
Research on molecular interactions and the separation and reaction characteristics of hetero-compounds	From the viewpoint of the comprehensive utilization of fossil fuel resources, hetero-compounds have been recently gaining attention as the raw materials for highly-functional materials. The objectives of this research are to clarify the interrelationships among the molecular structure, molecular interactions, and the separation and reaction characteristics of hetero-compounds, and to contribute towards the development of technology for high-efficiency, high-selectivity separations and reactions of hetero-compounds.	In connection with molecular interactions, researchers will investigate model nitrogen compounds' solvent-solute interactions and their interactions with adsorbents, and will clarify the connection between these molecular interactions and the molecular structure of nitrogen compounds. In connection with the extractability of hetero-compounds, researchers will investigate how the extractability of model nitrogen compounds is related to molecular structure and solvent-solute interactions. In connection with adsorptivity and desorptivity, researchers will investigate the adsorptivity of model nitrogen compounds with respect to inorganic adsorbents, together with investigating desorption methods using supercritical fluids, ultrasound waves, etc., and model nitrogen compounds' desorptivity. In connection with the reaction characteristics of hetero-compounds, the lab will investigate optimal catalysts for structure-conversion reactions involving quinoline rings, together with clarifying the relationships between molecular structure and all kinds of alkyl quinoline reaction characteristics.	National Research Institute for Pollution and Resources
Lifestyle Science and Technology			
Research on shape manipulation characteristics in human interfaces	In order to make the human interfaces of products and equipment systems used in everyday living and in offices comfortable to use, there is a need to represent the sense of manipulation as an integration of the human senses of vision, touch, and movement. The objectives of this research are to develop a visual and tactile information feedback type of manipulation environment for the purpose of manual shape manipulation in a virtual space; to clarify the characteristics of the human sense of shape manipulation; and to establish techniques for designing human interfaces that are very easy for people to get along with.	1. Measuring characteristics of shape manipulation that involves the use of multiple human senses In order to measure the sense of manipulation resulting from human hand movements in a manipulation environment, researchers will investigate the principles of and mechanisms for measuring movements without losing the degrees of freedom that the human hand possesses. 2. Developing a virtual manipulation environment that uses multiple senses In order to represent the virtual sense of manipulation, the lab will investigate high-speed, multiple-degree-of-freedom position and control systems that follow hand movements smoothly; control software; and methods for expressing the shapes that will be used in the environment.	Industrial Products Research Institute

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Biotechnology			
Research on conjugate-carbohydrate-related enzymes using new methods for measuring enzyme activity	In connection with glyco-proteins, in which sugar chains are covalently bonded with protein, and glycolipids, in which sugar chains are bonded with lipids—namely, conjugate carbohydrates—research is being conducted on (1) biofunction-regulating mechanisms at the sugar-chain level, e.g., research on the changes in the structure of sugar chains when cells become cancerous, the connection with animal nervous systems, elucidating the role of conjugate carbohydrates in immunological systems, etc.; and (2) technology for analyzing sugar chains, e.g., separation and refining technology, structure analysis, chemical synthesis, etc. Through research on conjugate-carbohydrate-related enzymes, which include sugar-conversion enzymes and enzymes that dissolve sugar chains, we will analyze sugar-chain structure analysis technology and also the biofunctions that have sugar chains. We will also conduct research on non-radioisotopic methods for measuring enzyme activity that use fluorescently-labelled substrates.	Synthesizing fluorescent glycolipids in which the fatty acid components of sphingo glycolipids are replaced with fluorescent fatty acids. Investigating the pre-requisites for mass production of bacterially-produced conjugate-carbohydrate-related enzymes.	Government Industrial Development Laboratory, Hokkaido
Bionics			
Research on surface-functional ceramics that is aimed at controlling biofunctions	In addition to the development of materials whose surface properties can be controlled, this research also aims at modifying ceramic materials for the purpose of actively controlling the production of substances by cells (biochemical processing) on their surfaces, e.g., coating ceramic surfaces with thin films, ion implantation, inducing functional groups such as amino and hydroxyl groups, and other methods to make the surface more "friendly" to cells and to bestow functions with which cell adhesion and multiplication characteristics can be selectively controlled.	<ol style="list-style-type: none"> 1. Techniques for modifying the surfaces of materials in order that cells have a greater affinity for them 2. Techniques for controlling the surface properties of materials in order to control the functions of cells on the material surface 3. Elucidating the functions with which attached cells recognize the structure of the solid surface of a material and the functions with which they respond to it. Aiming for active control of cellular physiological functions by means of ceramic materials, the first year of the research (1.) mentioned above will be to make the primary selection of ceramic materials. Because these materials will have to become the substrates for cells, researchers will select several kinds of materials on which the cells can readily attach and multiply. Of the research described in item (3.) above, researchers will investigate the conditions under which the cells' binding proteins bind to the surfaces of the materials selected. Examples of typical proteins that will be adopted are collagen and fibronecutine. 	Government Industrial Research Institute, Nagoya

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on information-integration processes in living organisms	Information processing in living organisms is said to involve the integration of many inputs as a result of those inputs passing through the networks of neural circuits and the forwarding of outputs that influence each of the senses. The objective of this research is to elucidate this information processing at the neural level.	<ol style="list-style-type: none"> 1. Research to elucidate the mechanisms of information integration in neurons Molecular-level clarification, with respect to functions and structures, of the way that interaction between sodium channels and membrane lining structures, which are the basic elements in the manifestation of excitation, should be in <i>Doryteuthis bleekeri</i> [squid]. 2. Research on image-learning processes of neurons Making cells learn discrimination tasks using easily distinguishable images while continuously recording neural activity from implanted electrodes. With this experiment researchers will collect data on the neural changes that occur during the learning process. 3. Research on information-generation mechanisms in olfactory nerve cells In order to study the correspondence between increases in the concentration of Ca^{2+} ions within a cell and the changes in membrane potential, researchers will produce a trial version of an optical system for measuring observable microfluorescence by means of fluorescent pigments that are sensitive to changes in membrane potential in 1-square-micron-size areas of olfactory cell membranes. They will also conduct studies on mathematical methods of analyzing information integration in the olfactory nervous system. 	Electrotechnical Laboratory
New Materials Technology			
Basic research on the synthesis of advanced functional materials from polynuclear aromatic compounds	In order to develop organic materials that have the merits of inorganic materials by creating materials that have the molecular-level functions of polynuclear aromatic compounds, i.e., stiffness, high electron density, light reactivity, etc., this research is to establish technology for changing the functional groups of polynuclear aromatic compounds by introducing substitutional groups into specific positions. Another objective is to conduct basic research for the purpose of developing advanced functional materials from polynuclear aromatic compounds that have these functional groups.	<ol style="list-style-type: none"> 1. Research on position-selective catalytic reactions of polynuclear aromatic compounds. —(A) The synthesis of efficient stereoregulatory catalysts by controlling zeolite's structure and configuration of oxygen points. —(B) Establishing the basis for technology with which to position-selectively introduce functional groups into compounds that have multiple reaction sites. Specifically, this involves studies centering on catalysts that speed up reactions such as carbonylation and vinylation of biphenyl derivatives. 2. Research on techniques for controlling the functions and structure of polynuclear aromatic compounds. Preliminary studies on the synthesis of functional materials from the compounds synthesized in the aforementioned research. 	National Chemical Laboratory for Industry
Research on the synthesis of biodegradable polymers utilizing carbon monoxide	In recent years, there is a remarkable increase in the volumes of used plastic products whose raw materials are synthetic polymers. Most plastics do not break down in a natural environment, and it has come to the point where we cannot ignore the influence that those waste products have on the environment. Social expectations are increasing with respect to the development of new polymers that will not pollute the environment—polymers like starch, cellulose, and other natural polymers that can be broken down in the ground or in the water by microorganisms. The objective of this research is to use carbon monoxide in establishing the technology that will become the basis for the synthesis of new biodegradable polyesters.	<ol style="list-style-type: none"> 1. Synthesis reactions Investigating the factors that control the molecular weight of polyglycolides. Concretely, investigating the influence that partial carbon monoxide pressures, including super-high pressures, and catalyst concentrations have on molecular weight. 2. Evaluating molecular characteristics Establishing methods for accurately analyzing molecular weight, molecular weight distribution, molecular structure, etc., of polyesters, centering on polyglycolides. 3. Evaluating physical properties Preliminary investigations of physical, mechanical, and other basic properties in addition to biodegradability of the polyglycolides obtained in the synthesis reactions in (1) above. 	National Chemical Laboratory for Industry

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on techniques for revealing the optical functions of organic thin films	To develop methods for predicting the optical functions of multi-layered film devices from analyses of the photoelectric fields in organic thin films in which anisotropy of molecular configuration is observed. Also, to search for organic materials whose optical characteristics change in response to external fields, and to uncover functions that can be adapted to thin film optical devices. Together with these research efforts, to gain a basis for the creation of new organic optical devices that are mainly an application of refractive index modulation.	1. Research on the theoretical design of opto-functional thin films Developing algorithms that take anisotropy into account for the purpose of calculating photoelectric field strength in multi-layered films. 2. Research on materials whose optical characteristics change in response to external fields Investigating the behavior of refractive index changes in photochromic organic thin films using equipment that measures the index of refraction in the near infrared region. Also, searching for photochromic compounds that show orientation responses in an electric field, and attempting to observe changes in their absorption spectra.	Government Industrial Research Institute, Osaka
Research on micro-laminated materials	Laminated materials in which different functions can be shared by various parts of the material are hoped to be the kind of materials that have both extremely high characteristics and multi-functionality. The objective of this research is to make possible the fine-texture design of laminated materials by making lamination units as small as tens of microns and by fine-controlling the structure of the layers.	In 1991 the lab will carry out the following research, the central theme of which is to grasp the basic and essential factors involved in the production of laminated compacts. 1. Investigating and evaluating the relationships between optimization of the scientific characteristics of surface electricity in the fine powders used as raw materials for sintering, and the powders' dispersivity and formability. 2. Investigating the basic control elements of centrifugal filter molding equipment for laminate molding.	Government Industrial Research Institute, Nagoya
Basic research on the manufacture of new carbon materials that is based on molecular design methods	To synthesize aromatic compounds whose molecular orientation is controlled by means of molecular design methods, then to solid-phase carbonize these compounds and thereby obtain carbon materials whose higher-order structure is controlled. To manufacture functional carbon materials that bring out, to the greatest possible extent, the functions that carbon potentially has, e.g., highly conductive and heat-resistant carbons, porous activated carbons, gas-impermeable hard carbons, etc.	With polyimide polymers as the main subject, to research methods for controlling the degree of molecular orientation, and to take into consideration their cyclization reactions and carbonization reactions. To investigate methods of measuring the degree of molecular orientation in the precursor and to clarify the correlation between that degree of orientation and the structure of the carbons obtained.	National Research Institute for Pollution and Resources
Research on techniques for manufacturing functional superplastic materials by means of powder methods	As industries become more advanced, the demand for functional materials is growing increasingly larger, and there are great expectations for that functionality to become more sophisticated. The objectives of this research are to develop new functional composites by combining superplastic materials with other functional materials, and to establish techniques for exploiting the functionality of superplastic materials.	Investigating techniques for refining the texture of Zn-22Al, a superplastic alloy of zinc and 22% aluminum, and techniques for producing composites of magnetic materials and Zn-22Al and solid molding them. In connection with the latter, investigating from the points of mainly mixing methods, molding temperatures, and molding pressures. Also, carrying out molding in a magnetic field orientation and investigating techniques for manufacturing high-performance superplastic composite magnetic materials.	Government Industrial Research Institute, Kyushu
Research related to the development of super-heat-resistant MoSi ₂ composite ceramics	Research objectives: —The development of new MoSi ₂ composite ceramics that have extremely high heat resistance. Research goals: —The development of super-high-temperature materials that can be used in air at temperatures of 1700°C and higher. —Creep-resistance (deformation speed): —1. At 1700°C and 1MPa, less than 10 ⁻⁸ /sec (Target value for horizontal-type heater materials) —2. At 1500°C and 100MPa, less than 10 ⁻⁹ /sec (Target value for turbine materials) Establishing methods for forging sintered bodies.	The manufacture of composite materials by means of various kinds of solid solution additives. Concretely, 1. Investigating various solid solution composites and elucidating the conditions for their manufacturing 2. Elucidating the characteristics of the composite materials obtained. 3. Investigating methods of forging sintered bodies as manufacturing methods.	Government Industrial Research Institute, Kyushu

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on the production of whisker composites and their characteristics	The goal is to establish technology for manufacturing aluminum-based composite materials that are reinforced with the borate-whisker materials developed at this lab. These composites are to be highly general-purpose and excellent in terms of abrasion characteristics and heat- and impact-resistance. This involves developing techniques for controlling whisker shape, clarifying their thermal and crystallographical characteristics, and evaluating the characteristics resulting from the production of composites from aluminum alloys and whiskers.	<ol style="list-style-type: none"> 1. To measure the changes over time of the reaction components in the synthesis of whiskers and to investigate the influence of component concentrations on the shape of the whiskers. 2. To measure the thermal conductivity of the whiskers and to investigate the relationship between that and the thermal conductivity of the composite material. 	Government Industrial Research Institute, Shikoku
Polymer Engineering Technology			
Research on polymer-metallic-cluster compound materials	Because conventional polymer-metallic-cluster compound materials are made by adding large quantities of metal powders, they do not necessarily make the most of polymeric materials' features, such as their light weight and ease of processing. Because metal clusters have different characteristics than bulk metals have, their applications are anticipated in all areas. This research involves producing polymeric materials that have new functions and high durability by combining these metal clusters with polymers, and it will help to uncover new application fields for polymeric materials.	<ol style="list-style-type: none"> 1. Creating polymer-metallic-cluster compound materials and elucidating their characteristics Investigating the conditions for synthesizing polymer-metal-complex compound materials, which are the precursors of polymer-metallic-cluster compound materials. Also, searching for spectra-based methods to analyze optical, magnetic, and other kinds of characteristics of polymer-metallic-cluster compound materials. 2. Evaluating the durability of polymer-metallic-cluster compound materials and elucidating their deterioration mechanisms. Investigating the process through which metallic compound materials are converted into metallic clusters when irradiated with electron beams and other kinds of beams. Also, exposing existing polymers to radiation and obtaining basic knowledge about their deterioration mechanisms in extreme environments. 	Research Institute for Polymers and Textiles
Research on techniques for controlling the functions of polymeric materials	It is known that polymeric liquids, gels, and composites exhibit phenomena such as polarization, stiffness variability and expansion variability in response to changes in electric and other external fields. This research is aimed at the creation of surface charge separation films, stiffness-variable materials, and other new materials in which external field response functions are exploited. Also, in order to bring out new functions and performance, we will establish techniques for accurately controlling external fields.	<ol style="list-style-type: none"> 1. Investigating the correlation between the surface charge of a formation film and electric field strength during phase conversion (solidification). 2. Experimental investigations of the effects of the shape, size, and concentration of fine particles in an existent polymeric fine particle-dispersive medium system. 3. Searching for materials that react to thermal and electric field changes together with measuring those reactivity characteristics. 	Research Institute for Polymers and Textiles
Reaction and Separation Techniques			
Research on reaction mechanisms in specific reaction sites and the creation of functional substances	As a result of the advancements in industry represented by electronics, chemistry, biotechnology, space, and marine fields, the development of substance synthesis methods based on new reaction sites and new reaction theories are strongly hoped for (11th report of the Council for Science and Technology). The objectives of this research are, in order to produce substances and materials that have been difficult to synthesize with existing technology, to create specific reaction sites that are anisotropic with respect to magnetic fields, density and concentration; to elucidate the mechanisms by which reactions occur in those sites; and to produce new functional substances.	<ol style="list-style-type: none"> 1. Designing a high-pressure super-critical fluid inter-reaction apparatus and the trial production of a part of that, together with measuring the physical properties of super-critical fluids that influence the reaction characteristics of chemical reactions, and searching for promising reactions. 2. Investigating methods for solidifying catalysts used in reactions or oxygen in gel (examples of reactions: as vibration-type reactions, the famous Belousov-Zhabotinsky reaction and the vibration-type oxygen reaction). 	National Chemical Laboratory for Industry

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on more advanced molecular recognition functions attributable to materials such as metal complexes	In future materials development fields, there is a demand for the development of materials whose high performance is due to the combination of the individual characteristics of the separate raw materials from which the composite is produced, e.g., metals, ceramics, organic materials, etc., or is due to their synergistic effects (11th report of the Council for Science and Technology: Basic, Pioneering Science and Technology Where New Developments Are Expected). The objectives of this research are to observe raw materials that recognize differences, at the molecular level, between structurally-similar substances, and by producing composites from these, to pursue the possibilities for more advanced naturally-manifest recognition functions or the manifestation of new functions.	1. Deciding on the metals and investigating methods for preparing the metallic compound materials. 2. Producing a trial version of an apparatus for evaluating the performance of separate raw materials.	National Chemical Laboratory for Industry
Research on atomic level design of highly-active metal catalysts	Solid catalysts have an extremely important place in not only the chemical industry but recently in electronics fields as well, e.g., chemical sensors and semiconductors. However, because solid catalysts have been developed on a trial-and-error basis until now, their actual atomic-level states are unclear, and they have not yet been optimized at the atomic level either. In order to break through this kind of situation, we will take up as an example metal catalysts, whose chemical characteristics depend heavily on their fine structure, and will develop techniques for precisely synthesizing solid surfaces, together with using computer graphics to build a model of the atomic structure of solid surfaces and developing methods for atomic-level understanding and design of catalyst functions.	1. The precise synthesis of catalytic activity spots: employing liquid-phase chemical methods, such as the sol-gel method, to synthesize ultrafine particles in which metal-to-metal-oxide junctions are integrated; clarifying their crystal structure, local atomic configuration, electron states, kinds of surface adsorbers, etc.; and investigating how the particle are related to catalytic activity. 2. Building an atomic structure model of catalytic activity spots: with computer graphics, making an atomic structure model of the interfaces where metals join with metal oxides.	Government Industrial Research Institute, Osaka

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on the design of organic ultrafine particles as reaction sites	Molecular aggregates (organic ultrafine particles), such as micelles and bimolecular films, have ionic surfaces and are considered to be that which is used as reaction sites for artificial enzymes and other such catalysts. The objectives of this research are to use the spin conversion interaction, a quantum phenomenon, to analyze intermolecular collision reactions, which are the most basic reactions, and to gain basic knowledge about molecular motion in reactions, together with elucidating the specificity of reaction mechanisms in these organic ultrafine particles and establishing guidelines for their optimal design as chemical reaction sites.	As organic ultrafine particles we will take up surfactant micelles; with respect to the spin conversion reactions of their solubilization radicals and adsorbing paramagnetic ions, we will measure temperature changes of their constant-speed reactions and evaluate activation energy. We will also take into consideration appropriate models of the diffusion processes for the types of reactions (solubilization radical and adion) at the micelle reaction sites.	Government Industrial Research Institute, Hokkaido
Systems Engineering and Applications Technology			
Research on dynamic skills	In present-day and future operating machinery there is a demand for technology that will efficiently control the dynamical systems of a broader range of structures by virtue of skillful utilization of the physical principles governing the movement of dynamical systems. To that end, this research involves actively using dynamical principles to develop new control methods (dynamic skills) for smoothly and skillfully moving dynamical systems that cannot be controlled with conventional control methods, e.g., mechanisms having degrees of freedom that do not have driving capacity and mechanisms that do not have fixed support points.	1. We will take up manipulators that have non-driving joints as objects to be controlled that have degrees of freedom without any driving capacity. In control, inertia, friction, and other such dynamical parameters that influence dynamical interference vary along with the operations. In order to cope with that, we will investigate applications of methods for automatically identifying those parameters, and will conduct experiments using motion measurement systems. 2. As an example of the control of mechanisms that do not have fixed support points, we will take up legged ambulatory robots that move dynamically. By switching among various dynamical models that differ in, for example, the constraint conditions for a multi-legged ambulatory robot, we will formulate models of control systems that correspond to the variations of support points, and will produce a trial version of a basic experimental device.	Mechanical Engineering Laboratory

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Information Technology			
Research on integrated processing of multi-phase information	In information processing that covers everything from symbols to patterns, information expressions and the content of their interpretation form the multi-phase structure that becomes the next information expressions. The objectives of this research are to elucidate and evaluate a framework for the integrated processing of this multi-phase information.	<p>1. Mathematical research in connection with the evaluation and approximation of information. Conducting basic research that involves the evaluation of information expressions, together with studying a basic framework for maximum-likelihood-approximation information processing. Concretely, to build upon the results of "soft logic" and conduct investigative studies on the efficiency of intelligent expressions, assessments that are based on various information processing standards, learning theories, maximum-likelihood estimations, optimization theories, and approximation theories.</p> <p>2. Research on techniques for expressing and utilizing multi-phase-type knowledge that are oriented towards partial-information problems</p> <p>—(A) Starting an investigation of methods for expressing problems that are based on partial information, and examining the criteria for differences between symbolic descriptions.</p> <p>—(B) Investigating a physical-model system that humans are thought to use when making judgments about the physical circumstances surrounding them.</p> <p>—(C) Starting a study on the stored expressions and the constraint sufficiency mechanisms of a knowledge model that has proof mechanisms.</p> <p>3. Research on continuous meaning networks</p> <p>—(A) Conducting research on time-series-processing networks that control inferential processes, and on optimized neural networks used for evaluating inferred results.</p> <p>—(B) Carrying out studies on turning neural networks into hardware.</p> <p>4. Research on adaptive expression and evaluation techniques for symbolic processing systems.</p> <p>—(A) Theoretical studies of methods for producing new expressions and evaluations that are suited to the nature of the problem by referencing examples of object-level problem solutions from meta-levels.</p> <p>—(B) Experimenting with control methods in the context of formula manipulation.</p>	Electrotechnical Laboratory
Industrial Base Establishment Technology			
Research related to a magnetic-levitation-type absolutely stationary stage system	This research aims at the realization of absolutely stationary environments, which are required in fields such as STM (Scanning Tunneling Microscope) and VSLI production, biotechnology, and optical equipment. The first objective is to develop a magnetic-levitation-type vibration insulation system for isolating micro-vibrational energy that streams in as disturbances from the floor and other parts beneath the stage. The next objective is to develop a three-dimensional-compensation-type absolutely stationary stage system that is "hard on top, soft on the bottom" and combines vibration-suppressing functions for dealing with agitations applied from the upper part of the stage, e.g., air fluctuations of which noise is typical, vibrations arising from equipment on top of the stage itself, etc.	<p>1. Developing super-vibration-isolation theories that will become the basis for an absolutely stationary stage system, together with investigating control methods that are based on these theories.</p> <p>2. Investigating and producing a trial version of a magnetic-levitation-type support mechanism, which is most appropriate as the basic component of a three-dimensional-compensation-type absolutely stationary stage system.</p>	Mechanical Engineering Laboratory

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on technology for manufacturing sheets of highly-functional metallic materials	To develop technology for directly producing high-ductility sheets that have continuously homogeneous fine crystal grains. Also, to conduct the basic research needed to establish technology for evaluating the design of a metallic materials manufacturing process that will demonstrate economy and productivity and in which the viewpoints of energy efficiency and resources conservation are incorporated, and to evaluate technology for manufacturing sheets of highly-functional metallic materials.	1. To revamp a stirring synthesis test apparatus and change it into machinery that can continuously transfer semi-solid slurries containing homogeneous fine crystal grains to a rotary caster that is to be set up in the next fiscal year. 2. Using the revamped stirring synthesis test apparatus, to implement experiments in which slurries will be continuously produced. 3. To carry out the primary conceptual design of a materials manufacturing process that reduces the burden on the ecosystem.	Mechanical Engineering Laboratory
Research related to virtual air-conditioning machine technology	To develop virtual air-conditioning machine technology that would enable machine tool control to be adapted to fluctuating processing atmospheres in order to compensate for the effects that instability in the temperature of the processing atmosphere has on lowering the precision of workpiece processing. Also, to conduct the basic research needed to evaluate the design of a machining process that will demonstrate economy and productivity and in which the viewpoints of energy efficiency and resources conservation are incorporated, and to conduct evaluations of virtual air-conditioning machine technology.	1. To conduct studies on the input variables, basic structure, and learning methods of a learning-type control system, and on measurement methods used in process monitoring. 2. To carry out the primary conceptual design of a machining process.	Mechanical Engineering Laboratory
Interregional Research			
Next-generation advanced production system	The next-generation advanced production system is an open-ended, integrated system that has a high degree of compatibility, extendability, and transparency; it must be a modular-type integrated system whose modules have a high degree of constructability, inter-connectability, and general-purpose characteristics. Harmonious growth of worldwide manufacturing industries requires the technology that makes these qualities possible to be commonly owned as technology for a common international base. As a part of the ten-year-long IMS project, this research is to establish, through joint international R&D, production component technology and production system technology that is open-ended and highly integratable, modular, and autonomous.	Investigating concepts of and necessary conditions for a next-generation advanced production system and the characteristics that its elemental technology should have, and starting basic research on highly-advanced elemental technology.	Mechanical Engineering Laboratory Electrotechnical Laboratory National Research Laboratory of Metrology

Research Heading	Objectives	Content of FY1991 Research	Name of Research Institute
Research on high-temperature-use fiber-reinforced ceramics	The practical application of ceramics that have excellent heat resistance and can be used under extreme conditions is sought after in leading-edge technologies. In comparison to metals, however, ceramics are brittle and not very reliable in terms of strength, so their practical application as high-temperature materials leaves much to be desired. Using fibers in the production of ceramic composites is thought to be extremely effective way to improve their brittleness, which is necessary in order to make ceramics more reliable. To that end, this research involves investigating various techniques for producing fiber-reinforced ceramics, together with improving the surface quality of the ceramics by means of ion engineering methods and trying to improve their mechanical characteristics. This research also involves characterizing the fiber-reinforced ceramics that are produced and establishing a basis for contributing to the development of high-temperature-use fiber-reinforced ceramics that are very strong, tough, and reliable.	1. Technology for producing fiber-reinforced ceramics —(A) Fiber-reinforced ceramics using organic silicon polymers. In order to understand the problem points that result from impregnating an organic-silicon-polymer-based slurry into a preform, researchers will conduct basic investigations on the wettability of various fibers and organic silicon polymer solutions, and the conditions for high-density impregnation. —(B) Highly-heat-resistant oxide compound ceramics Investigating the conditions for producing high-heat-resistance, high-toughness fiber-reinforced ceramics by compounding whiskers into high-melting-point oxides (e.g., light rare-earth oxides, zirconia, etc.). —(C) High-temperature-use ceramics from C-C composites Investigating the reaction characteristics of metal-silicon alloys and carbon fibers, and metal-silicon alloys and matrix carbon; studying the conditions under which carbon fibers do not react much with metal-silicon alloys and the conditions under which metal-silicon alloys react easily with matrix carbon. —(D) Improvements in mechanical characteristics using ion engineering As a preliminary to applying ion engineering technology in fiber-reinforced ceramics, we will try to implant various kinds of ions in simple ceramics and will investigate the effects on mechanical characteristics. 2. Characterization of fiber-reinforced ceramics Each of the labs will carry out evaluations of the mechanical characteristics (bending strength, hardness, elasticity, etc.) at room temperatures of the fiber-reinforced ceramics produced. As for toughness, researchers of the three labs will collaborate in the investigation of methods for evaluating the toughness of the ceramics and will clarify problem points.	Government Industrial Research Institute, Osaka Government Industrial Research Institute, Nagoya Government Industrial Research Institute, Kyushu
Research on controlling the structure of amorphous polymeric materials and on evaluation methods	Elucidating the relationship between the structure and physical properties of organic polymeric glass is extremely important in the application of organic polymeric glass as an optical information material, but methods for evaluating amorphous structures have not yet been established. Establishing those methods is becoming an essential point that will accelerate the development of technology for producing materials with higher performance and higher functionality by means of controlling their structural properties. The aims of this research are to establish methods for analyzing and evaluating the amorphous structure of polymeric materials, together with establishing the fundamental technology for materials development that is based on controlling amorphous structure.	1. Because the previously proposed sorption-expansion theory assumes simple microvoid dispersion, we will try to expand that theory to include polydisperse systems. We will develop high-temperature measurement techniques for measuring the adsorption and expansion parameters of the rubber state, which will become the standard for evaluating amorphous structures. Also, we will investigate methods for measuring and evaluating optical characteristics. 2. We will investigate methods of volumetric structure control by means of a low-molecular-concentration swing at room temperatures. We will also investigate methods of volumetric structure control by means of hydrostatic pressure.	Industrial Products Research Institute National Chemical Laboratory for Industry Research Institute for Polymers and Textiles

Canon CEO on European Strategy

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[Interview with Takenori Matsuoka, chairman of Canon France, by Herve Marchal: "Growth Has Become a

Mania"; first paragraph is ENTREPRISES & TELECOMMUNICATIONS introduction]

[Text] France is Canon's number one market in Europe, and Europe is its number one in the world market. This illustrates the importance of the Old World—and our country—to the Japanese firm's strategy. This firm has

an enviable growth rate: a 450-percent increase in revenues over the last 10 years. And this is just the beginning. The objective henceforth is to multiply revenues by a factor of five and double the number of personnel between now and 1995. To achieve this, a further effort will be made in research and development, the telecommunications challenge will be taken up and, above all, the burning issue of internationalization will be tackled. Even if this means paying the ultimate price: diluting the distinctive Japanese character of the company.

ENTREPRISES & TELECOMMUNICATIONS: Is the strategy of Canon France specific to France or is it part of a wider European strategy?

Matsuoka: The objective of Canon France, of which I am chairman, is not specific to France. Our aim has always been to contribute to the development of the country in which we are established. The general policy of the group today, which was determined recently, is to reach a 15-percent annual growth rate. This means that we will try to double our revenues in five years. However, with empty hands, this will be impossible even if a market does exist. In other words, without our products and technology, we will not be able to achieve this. But I am confident because the directorate of research and development (R&D) is going to help us sustain our normal, standard growth rate enabling us to maintain our development. This is of utmost importance.

ENTREPRISES & TELECOMMUNICATIONS: You mentioned R&D; about a year ago, Canon France laid the foundation stone for a research and development center in Rennes. How is this center developing, what fields will it be working in, and how many researchers will it have?

Matsuoka: The group has a major philosophy: the philosophy of globalization. To appreciate Canon in its totality, its three main activities—R&D, manufacturing, and marketing—must be considered. We would like, over the long term, for all our products sold in Europe to be developed and manufactured there. France is, furthermore, the first country in Europe where our three activities have been combined. Our first, purely marketing, operation started up in 1975; then, in 1983, we launched the Liffre plant in Brittany; and at the end of 1990, the research center in Rennes. This last operation is, considering our global policy, something we see as being essential. We are happy that the main orientation of the center is telecommunications, because this field is highly developed in France. As for recruitment, this will be rapid: about 100 engineers in three years. So I am happy to be able to tell our marketing people that we will soon be selling products developed in France.

ENTREPRISES & TELECOMMUNICATIONS: Are these researchers recruited from the European market or throughout the world?

Matsuoka: Canon chose the Rennes Atalante site because it is an area rich in human resources, with universities and colleges where engineers are relatively

easy to find. But this center, the second of its kind in Europe, is called Canon Information Systems R&D Europa, which means that it has a European, and not a purely French, dimension. Furthermore, all products manufactured in Brittany are destined for the whole of Europe. Therefore, recruitment will be European.

ENTREPRISES & TELECOMMUNICATIONS: In what telecommunications sectors will the center concentrate its activities?

Matsuoka: In our business when we talk about telecommunications we are talking, first and foremost, about fax machines. But very few boundaries exist between our products. For instance, our laser color copier is a photocopier with enormous potential for interconnection with microcomputers, PCs. The same goes for fax machines. There are endless possibilities for communication with other computerized office equipment. Let us say that our main focal point will be the future fax machine applied to the world of office technology.

ENTREPRISES & TELECOMMUNICATIONS: Do you envisage new products being developed at this research center?

Matsuoka: Of course, this is our main objective. We are carrying out operational research and development there.

ENTREPRISES & TELECOMMUNICATIONS: On the basis of information provided by your group, over two years ago, the staff in the Liffre plant in Brittany was working harder than the staff in Germany; as hard as the staff in Japan; and nevertheless, was paid much less. How can you explain these differences?

Matsuoka: The local context is taken into consideration, in this case, the average salary level for this kind of activity in Brittany. In any case, for France, it is more logical to take salary levels existing in Brittany as a basis rather than those existing in Germany. I would add that there is nothing comparable in Germany to the French system of participation.

ENTREPRISES & TELECOMMUNICATIONS: Are you satisfied with your staff?

Matsuoka: Absolutely.

ENTREPRISES & TELECOMMUNICATIONS: Do you have plans for growth abroad?

Matsuoka: Why not? We do not want to hold back from cooperating with French or European companies. It all depends on the field in question, on our priorities, and those of our partner. There are a certain number of examples of this: a joint venture with Olivetti in Italy; Canon Inc. has an agreement with Siemens in Germany concerning the PABX (we distribute Siemens' line of Saturn automatic exchanges in Japan). But we have no new projects in France for the moment.

ENTREPRISES & TELECOMMUNICATIONS: Don't you control the activities of the small French manufacturer Tetras?

Matsuoka: Yes, Canon Inc. Tokyo has a 19-percent stake in this photocopier company. But I believe that this company is developing from marketing to manufacturing only. There are no plans for a major cooperation with it. The main business remains focused on manufacturing.

ENTREPRISES & TELECOMMUNICATIONS: The European Community accused you of dumping and levied a tax on you five years ago. Does this stricture still apply?

Matsuoka: This represents a tax of 20 percent over and above the price for certain photocopy products. This penalty is still in force. I hope that it will be lifted soon. But this is not the fundamental problem. I believe that this antidumping measure is fairly typical. It is a symbol of protectionism. Canon and a certain number of Japanese manufacturers exported finished products to other countries. It is true that they won over these markets. But Canon has a very clear policy. It is not our intention to make money on external markets and then to transfer the profits to Japan. We have never done that. We want to maintain our presence in France. Furthermore, I am working for France and this motivates me a great deal. I want to be a foreigner who is working for your country. Canon has, for nearly five years now, manufactured several lines of photocopier products in Europe and the United States, outside Japan. In my opinion, this is no dumping but the essence of Cannon's policy. At that time, and purely by chance, we were fined and our point of view was not given full consideration, but our policies are very clear today.

ENTREPRISES & TELECOMMUNICATIONS: How can you explain the price differences between the European market and the Japanese market?

Matsuoka: Our position is not that there was 20 percent dumping. We fully explained our point of view, but this resulted in our being fined. That is history. What we want now is to progress. Today, we have no product that can be the object of dumping. In effect, we do import laser color photocopiers but these are very high-technology products and are not included in antidumping legislation. We have always wanted to increase the manufacture of products sold in Europe.

ENTREPRISES & TELECOMMUNICATIONS: Are products which are made in Europe exported elsewhere in the world?

Matsuoka: They are intended for different European countries and, during a subsequent phase, for the whole world.

ENTREPRISES & TELECOMMUNICATIONS: What percentage of the Liffre plant's production is exported within Europe?

Matsuoka: Roughly 20 to 25 percent of the products are sold in the French market, the remaining 80 percent is exported to other European countries.

ENTREPRISES & TELECOMMUNICATIONS: You have decided to strengthen your operations in the United States, notably for software production.

Matsuoka: We have a research center there dealing in software for computers and peripherals. And we have set up a telephony unit there recently. On a more global level, we have several transfer projects for certain activities. Full-fledged divisions will be transferred out of Japan. We need to do this to develop our technologies. This is one of the main reasons the development, planning, and marketing department of the typewriter division is being moved to the United States.

This is a good example of the principle of decentralization. I believe that we are trying to move to countries most advanced in each field. Canon has fully understood that to become a worldwide leader in a given field, it is necessary to seek skills in countries where they exist. This is why we also created a research center in Australia a short while ago. We try, in each case, to match the culture and technical progress of each country.

ENTREPRISES & TELECOMMUNICATIONS: So far we have not been able to speak of a major Canon breakthrough in computer equipment. How can you explain this?

Matsuoka: We sell a certain number of PCs—the central component of computerized office equipment—and perhaps we are not as well known as Macintosh. It is true, too, that Canon has no intention of venturing as far into this field as Apple or IBM. Our policy lies more in the development of a very wide range of computerized office equipment, although in France over 50 percent of our business comes from photocopiers. In fact, Canon has a piecemeal approach. This system enables us to have a foot in every door permanently. We now want to give priority to software because we are aware of its importance. Our president's policy is to have hardware in our right hand and software in our left.

ENTREPRISES & TELECOMMUNICATIONS: What are the requirements of enterprises going to be over the next 10 years in terms of telecommunications and computerized office equipment? What types of products will need to be developed?

Matsuoka: In our business, no one is able to predict the next generation of office technology products. There are many products nowadays that were not even planned five or 10 years ago. There are many opportunities for innovation and I have no idea of the latest. But there are a certain number of significant parameters which help understand where we are heading, for example the personal systems market. When we talk about office automation, we increasingly talk about personal office products such as the personal laser color copier, the personal fax, and the personal telephone. The second significant

factor is the systems approach. Canon is investing a great deal to ensure that systems are compatible, that products can be interconnected and communicate with each other. In other words, interfaces and software are the mainstays.

ENTREPRISES & TELECOMMUNICATIONS: Do you think that the senior executive is going to use all this computerized office equipment personally, or is it essentially going to be used by assistants, secretaries, or junior executives?

Matsuoka: I think that progress is less rapid than expected for the simple reason that these products are still too sophisticated and directors do not have the time to work with the machines and learn the technicalities. This must all be made more simple. The use of vocal commands is going to facilitate things greatly and make operations much easier. But I am skeptical. The executive occasionally uses a typewriter, the photocopier, and, from time to time, sends faxes. It is, however, very rare to see a computer on his desk.

ENTREPRISES & TELECOMMUNICATIONS: Is this as true for Japan as it is for the United States and Europe?

Matsuoka: Yes, generally, but things are changing. Young executives have a microcomputer in their homes.

ENTREPRISES & TELECOMMUNICATIONS: And how about you?

Matsuoka: I have a Navi, a workstation which operates on Kanji, the Chinese alphabet, and is therefore impossible for a European to use. The American version was named Navigator.

ENTREPRISES & TELECOMMUNICATIONS: The Navi has experienced start-up difficulties in Japan. But it is a machine that combines many useful functions. One suspects that its commercial career does not quite live up to expectations. Why is this?

Matsuoka: It combines five or six functions: telephone, fax, word processor, computer.... This kind of product always takes time to win over the general public. The second generation is more compact, less expensive, and is slowly gaining ground. It is a marvellous piece of equipment.

ENTREPRISES & TELECOMMUNICATIONS: It is an excellent product yet it has not made the breakthrough expected of it....

Matsuoka: It is more or less the same in the United States, the results were not as expected. I think it is a behavior problem, people are not ready for it. The Navi and the Navigator are products that are far ahead of their times. The executive is not ready to shed his fax, his microcomputer, his typewriter, his everyday environment and replace them with a single box.

ENTREPRISES & TELECOMMUNICATIONS: What level of investment in R&D do all these products involve?

Matsuoka: Canon invests about 10 percent of its sales figure in R&D and is currently setting up eight research centers throughout the world. We have 54,000 employees in the group, 10 percent of whom are involved in research.

ENTREPRISES & TELECOMMUNICATIONS: They say that you register quite a lot of patents? Can you give me a figure?

Matsuoka: We were number one in the United States in 1987 with 868 patents. There are no significant figures for Europe: The United States is really the reference point because all major companies register patents there. We were in third place in 1990 with 885 patents behind Mitsubishi in first place and Toshiba in second. Companies such as IBM or Rank Xerox are ninth and 33rd respectively (source: IFO).

ENTREPRISES & TELECOMMUNICATIONS: In Japan, you are number two in photocopiers, number two in word processing, and number three in faxes. Why are you not first in any of these fields?

Matsuoka: First of all, Canon is a generalist. Furthermore competition is much more fierce in Japan for office technology than in the United States. Each manufacturer has its own specialties. Ricoh specializes mostly in photocopiers. Canon, however, has tried to diversify into optics, photography, office technology.... Therefore, not being number one is normal. It is very difficult to be a generalist and to remain leader in one sector. However that may be, diversification is a very important strategy because if we had been strong in photocopiers only, there would be very little potential for future development.

ENTREPRISES & TELECOMMUNICATIONS: Canon Inc.'s major objectives for the next few years are to reach 100,000 employees worldwide, to multiply revenues fivefold, and to invest in new fields such as telecommunications and everything in relation to audio-visual technology. These objectives give the impression of a growth mania. Do you think they will be reached?

Matsuoka: We would like our sales figure in France to reach 8 billion french francs [Fr] in 1995, compared to Fr4 billion in 1990. This represents an annual growth rate of 15 percent, which is enormous considering that the market has reached maturity. Do we have what it takes to achieve this? I think so. I cannot say that we will be five times stronger in 10 years time, but it is our intention to try.

ENTREPRISES & TELECOMMUNICATIONS: A Tokyo newspaper, the NIKKEI SANGYO SHIMBUN, estimated a couple of weeks ago that "for those manufacturers who are at the very heart of the industry, technology is a vital element. However," it added, "if our manufacturers are reluctant to share their 'treasures,'

they will never be able to rid themselves of the Japanese label. It is a choice that must be made," the newspaper concluded. Has Canon chosen to become less Japanese to be able to expand to a greater extent worldwide?

Matsuoka: Yes, very much so. When we refer to the Canon company, we mean the Canon Inc. company in Tokyo, but it is true that in France Canon is considered a Japanese company. It is true that there is a Japanese CEO and French investment, but most of the shares are now held by European shareholders, of Japanese origin of course. There is a marked tendency to try to become a truly French company. I do not think that this is making rapid progress, but we do not intend for Canon to become a Japanese brand. Canon will still mean photography, photocopiers, yes, but its origin? Chinese, American? No, international. Canon is already present in France through its research centers, its factories, and its marketing companies. But is it really a French company? Of course, its major shareholder is Canon Inc., but President Yamaji announced at the inauguration that we would have about 100 engineers in three years, of whom only six or seven will be Japanese; the others will be European. And in the long term, there will be a French director at the head of the R&D center.

ENTREPRISES & TELECOMMUNICATIONS: Will Canon have to become an American-style multinational to become truly international?

Matsuoka: Not quite. In other respects, the weight of the American market is not the most important. In terms of consolidated revenues, Europe is in the lead with 33 percent, followed by the United States and Japan with 30 percent each, and 7 percent for other countries (Australia). Therefore Canon's most important market is Europe.

ENTREPRISES & TELECOMMUNICATIONS: Do you think that the European share as a percentage of your revenues is going to increase even more?

Matsuoka: Yes, the lifting of borders and the unification of the European market represent a most important phenomenon. It is excellent for European countries. It is also beneficial for us. And I hope that the Economic Community will not be a closed community, but one that is open to the world.

[Box, p 91]

Mister 1,000 Percent

If anyone knows about Canon France's excellent results (a growth in revenues of 1,000 percent between 1980 and 1990), it is Takenori Matsuoka who, at 52 years of age, has been CEO of the French subsidiary since last January. After spending five years in the Toride mother factory in Tokyo, Takenori Matsuoka arrived in France in 1983 as vice president responsible for administration. This manager, who speaks excellent French, is today at

the head of Canon's most important outpost in Europe. Will he be known as "Mister 1,000 Percent" from now on?

[Box, p 92]

In France: 2,550 People and Four Subsidiaries

After 15 years activity in mainland France, Canon recorded Fr5.5 billion in revenues in 1990, i.e., an increase of 1,000 percent since 1980. As for the number of staff, it has risen to 2,550 people in four divisions: Canon France SA, founded in 1975, markets office technology and computer equipment; Canon Photo Video France SA, created in 1979; Canon Bretagne SA, established in Liffre in 1983, focuses on the manufacture of fax machines; and Canon Information Systems R&D Europa SA, created in 1990, is a research center with a European orientation located in the Rennes-Atalante "technopolis."

On a world scale, Canon Inc. employs 54,000 people for a sales figure of Fr65 billion in 1990, i.e., a multiplication by four and a half in 10 years. Spending in research development (R&D) represented 11.3 percent of the consolidated revenues. The office equipment sector (photocopiers, faxes, laser printers) constitutes the greater percentage of the result, some 78.8 percent. Photography and video, on the one hand, and optics, on the other, complete the range.

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Japan Makes Inroads in EC Robot Market

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31 May 91 p 9

[Article by Richard Mieczkowski: "Japan Takes Lead of Robot Market—Over 1,000 Robots Installed in the Netherlands"]

[Text] Utrecht—Through 1989, two-thirds of the robots purchased in the Netherlands were European products. After 1989, this market share plummeted to 33.6 percent. Japanese suppliers have taken charge. Of all robots sold in the Netherlands, 45.6 percent are now Japanese. Through 1989, the Japanese share was 10.4 percent.

During the "Matic '91" factory automation fair held in Utrecht, Eng. I. Vermeulen, director of the Bilthoven-based Anertek market research and training bureau, reported that in September 1990 the 1,000th robot was installed in the Netherlands. Since 1986, the Dutch robot population has been one of the subjects researched by Anertek. During those years, annual robot sales varied from 140 robots in 1986, to 120 in 1987, 138 in 1988, and 168 in 1989. In 1990, 160 robots were installed. At this moment, 1,091 robots are in operation, according to Vermeulen's estimates. This count includes the SCARA, a somewhat simpler, four-axis robot.

Japan's advance is especially striking in the robot market. The biggest user of robots is Volvo Car.

According to Vermeulen, this originally Dutch car factory in Born has been degraded to "just an assembly plant for its Japanese (Mitsubishi) and Swedish (Volvo) owners." Vermeulen said he feared for the European robot industry, "because if Mitsubishi buys a robot, it will not be an ASEA." He thinks that the majority of autonomously operating robots will be of Japanese origin anyway. The more complex robots, which are part of a larger system, will remain European (German or Italian) for the time being. Not because the Japanese cannot produce these, but the numbers sold are so small that they are not commercially rewarding. From the consumer's point of view, good communication with the supplier is important and communication with Japan is difficult, according to Vermeulen.

A repercussion of Japan's supremacy favorable to the consumer is that prices are going down. "Robot prices have gone down to Japanese levels," says Vermeulen. Whereas 150,000 guilders for a new six-axis robot was normal five years ago, these now cost an average of 80,000 guilders. The struggle for market shares is being fought in the middle bracket, because 240,000 guilders or more is readily being paid for a top model.

Of the 33.6 percent robots of European origin, ASEA is the largest manufacturer with 20.4 percent (down from 47.2 percent before 1989). Kuka is a stable runner-up with a steady 6.6 percent share, but is vulnerable due to its complete specialization in robots for the automobile sector. IGM was able to increase its market share from 3.7 to 4.5 percent. Cloos went down from 5.9 to 2.1 percent and Reis (previously 1.3 percent) no longer appears in Anertek's charts.

Although the share of U.S. robots has decreased only slightly from 11.1 to 10.5 percent, this group was wiped from the market with the exception of Adept. IBM's market share decreased from 6.6 to 1.5 percent. Unimation (previously 3.3 percent) has also disappeared from the charts. Adept's market share increased from 1.2 to 9 percent, but Vermeulen questions the U.S. nationality of this manufacturer.

In the Japanese quarter, the market shares of all brands have increased. Panasonic even managed to become the absolute market leader from out of nowhere in three years (22.8 percent). Hitachi rose from 4.6 to 8.7 percent, GMFanuc went up from 1.7 to 7.8 percent, and OTC from 2.5 to 6.3 percent.

Hitachi's success also caused Valk Welding to become the largest Dutch robot supplier with a 28.5-percent share of the market (up from 12.6 percent). ASEA Brown Boveri's (ABB) share as supplier (the ASEA brand is also supplied via other companies) went down from 33.6 to 15 percent. Other climbers are EMB (from 1.2 to 9 percent, especially through Adept's SCARA robots), Geveke Electronics (from 4.4 to 8.7 percent), Landre (from 1.7 to 7.5 percent), and Morelisse (from 0.9 to 6.3 percent). Philips' market share decreased from 1.7 to 0.9 percent, but these are mainly in-house supplies.

An interesting development is the use of robots in the food industry, where they are mainly used for packing small batches (diabetes products, small export series) in varying packages. Eng. J. Bouwman of EMB Techniek praises the rapid convertibility of robots. As an example, he mentions the filling of tubs of margarine. Sometimes the maximum filling line has to be modified four or five times a day for different tubs, which is a "terrible burden." Using robots makes this faster. Moreover, hygiene is improved and quality enhanced. Another reason for using robots in the food sector is their reusability when the packaging has undergone a drastic change. "Normally, millions of guilders are wasted in converting a packing line to a new packaging," Bouwman observes.

Governmental Proposal for Global Warming Prevention Plan

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[Proposal by the Prime Minister's Council for Preservation of the Global Environment]

[Text]

An Action Plan for the Prevention of Global Warming

This Action Plan for the Prevention of Global Warming (referred to below as "Action Plan") is based upon the "Review of Present Measures Against Global Warming" (Agreement by the Prime Minister's Council for Preservation of the Earth's Environment on 18 June 1990).

Part 1. Background for Determination of the Action Plan and its Significance

The problem of global warming is a grave problem which threatens to severely affect the foundations of human existence. According to the report by the Intergovernmental Panel on Climatic Change (IPCC), if the emissions of gases that cause the greenhouse effect continue at their present rate, a rapid increase in temperature will occur, a situation which has not been seen for the past 10,000 years. As a result, it is predicted that severe effects on natural, economic and social systems, such as a rise in the sea level, changes in climate, and threats to the human habitat will come to pass.

The preservation of a good global environment, which is the basis for the survival and growth of future generations, is the sacred duty of our generation, which is presently reaping the benefits of this global environment. In recognizing this fact, although many areas concerning global warming remain scientifically unresolved, it is necessary for the various nations of the world to join forces and steadily implement practicable measures without delay to ensure that the damage will not reveal itself in circumstances from which recovery is impossible.

Therefore, our country must play a positive role in accordance with our position in the world by utilizing our economic and technical strengths to aid the developing nations of the world. As a result of efforts on the part of both government and the private sector to utilize energy efficiently, Japan belongs to the group with the lowest per-capita carbon dioxide emissions among the industrially advanced nations. Yet, our nation still emits a large amount of carbon dioxide, and these emissions are continuing in their trend of the past few years to increase due to changes in the lifestyle of our people and prosperous economic activity, which are reflections of the increase in domestic demand in recent years.

Emission controls on greenhouse gases should be implemented after full consideration of the severity of the effects from global warming and the practicability of control and adaptation measures, while planning for stable economic expansion in line with the concepts of sustainable growth. It is necessary for Japan to attain stabilization of greenhouse gas emissions rapidly as the first step in a common international effort to control the emissions of greenhouse gases.

Moreover, the loss of forests, which are resources for carbon dioxide absorption, is occurring on a worldwide scale. In light of our nation's relationship to the forest resources of the world, it is necessary for Japan to take the initiative in forest conservation, and in the prevention of their destruction in line with the concepts of sustainable growth.

Furthermore, in order to determine appropriate measures on the basis of scientific knowledge for reducing uncertainties about global warming, not only must we conduct research, observations and monitoring, but we must also strive for even greater development and dissemination of technology, including innovative techniques.

In light of the various situations noted above, we shall explicitly state the policy of this present government for promoting systematic, comprehensive countermeasures to deal with global warming and present an overview for a practicable plan that should be pursued in the future. Thus, we present this Action Plan that shall clarify our basic position, not only to obtain the understanding and cooperation of our citizenry, but to make our nation's contribution as part of the international framework.

Part 2. Basic Items to be Considered in Implementing Countermeasures Against Global Warming

1. Formation of a Society that Preserves the Environment

In order to prevent global warming, it is necessary to implement a variety of wide-ranging, long term measures

in all sectors of society and, in this respect, the understanding and active cooperation of the people is indispensable. Based on this understanding and cooperation by the people, in order to prevent the excessive concentration of urban and economic functions within the country, it will be necessary to work toward an appropriate balance between the environment and human activity in the nation as a whole, and to reconsider extensively the socio-economic system as well, including the formation of urban organization and transportation systems that do not readily emit greenhouse gases. It will thus be necessary to create a society that places only a small burden on the global environment by converting the lifestyles of the people to those that take the environment into consideration and work toward the establishment of an environmental ethic.

2. Compatibility with Stable Economic Growth

Global warming is a problem that is linked to all aspects of our daily lives and our economic activity. Measures taken against global warming will affect the world economy with its deep mutual interdependence in a variety of ways. Therefore, to solve the problem of global warming it will be necessary to work toward its compatibility with stable economic expansion in line with the concepts of sustainable growth by strengthening the ties between economic and environmental measures, making technological breakthroughs, etc.

3. International Cooperation

Because the causes and effects of global warming occur on a worldwide scale, not only the efforts of individual nations, but international cooperation as well is indispensable for dealing with this problem.

More specifically, based on predictions that the emissions of carbon dioxide will rapidly increase along with future world population growth and economic development and in light of Japan's superior technology and wealth of experience in environmental conservation, our nation must take the lead in this internationally-cooperative world struggle.

From this standpoint and with a long-term view in mind, Japan has worked toward bringing about an international agreement on the necessity of cooperative action in creating a comprehensive, long-term vision (World Rebirth Plan) that will include the various countries of the world in a cooperative effort to build a firm scientific foundation, promote conservation of energy and energy resources, introduce clean energy, develop innovative environmental technology, increase greenhouse gas absorbing resources, and develop next-generation energy technology. From now on, however, Japan must give impetus to the concrete realization of these items based on the Action Plan.

Part 3. Goals of the Action Plan

The emission control goals for greenhouse gases are as follows:

(1) Concerning carbon dioxide, the following goals have been set based on the premise that the various industrially advanced nations will make a common effort to control emissions.

—(1) Through the maximum efforts of the government and private sectors, we will faithfully implement the wide-ranging measures included in this Action Plan, beginning with those most practicable, to control carbon dioxide emissions, and we will work toward stabilizing the amount of per-capita carbon dioxide emissions after the year 2000 at roughly 1990 levels.

—(2) In accordance with the various measures in 1) above, we will further strive to stabilize total carbon dioxide emissions after the year 2000 at roughly 1990 levels by the development of new energies, such as solar and hydrogen energy, and the development of innovative techniques, such as carbon dioxide fixation, both sooner and more extensively than presently forecast.

(2) Methane emission will be controlled so as not to exceed its present level. Emissions of nitrous oxide and other greenhouse gases will be controlled so as not to increase at all.

Concerning carbon dioxide absorbing resources, we will work toward complete maintenance of the nation's forests and urban greenery, and will actively strive for preservation and reforestation on a worldwide scale.

Part 4. Duration of the Action Plan

The duration of the Action Plan shall be from 1991 to 2010 with the year 2000 as the year for mid-term goals. During this time we will conduct reviews of the Action Plan as necessary in light of international trends and accumulation of scientific knowledge, and respond in a flexible manner.

Part 5. Measures to be Taken

The government will implement the following measures to attain the goals of the plan beginning with the most practicable ones. In doing so, it will take sufficient care that the implementation of the measures against global warming will not cause or intensify other environmental problems.

I. Measures for the Control of Carbon Dioxide Emissions

In addition to a wide-ranging review of the *status quo* of our nation's urban and district structures, transportation systems, industrial structure, energy supply structure and lifestyle, we will promote the development and dissemination of technology and implement the following measures comprehensively.

1. Formation of Urban and District Structures that Limit Carbon Dioxide Emissions

In addition to working toward the assurance of a good environment for habitation centered mainly around urban areas where various activities are concentrated, we will attempt to form urban and district structures that limit carbon dioxide emissions.

—(1) Through the implementation of "urban greening," we will make use of the temperature-lowering effect of plants to moderate the urban climate by alleviating the heat island phenomenon, and reduce the energy demands needed for refrigeration.

—(2) We will implement thermal insulation in architectural structures such as houses, work to promote the dissemination of energy-saving architectural structures such as the passive solar house, and promote positive utilization of natural energy with solar water heaters, solar systems, solar batteries and the like in architectural structures.

—(3) We will develop nitrous oxide reduction technology while working toward compatibility with existing electrical generating systems, and we will promote the introduction of cogeneration systems (systems that supply both thermal and electrical energy) with fuel cells in a form that leads to increased energy efficiency.

—(4) Through the use of heat pumps we will utilize the low temperature heat emissions that accompany urban activity, such as from subways and sewers, and the thermal energy possessed by rivers and the sea as a source of heat for air conditioners and heaters, and we will promote and implement thermal supply systems to districts that utilize these sources.

—(5) We will actively promote the utilization of supplies of excess heat that accompany the incineration of waste, the energy produced by the generation of electricity, and that from sewage sludge. We will also work toward efficient utilization of the energy required for the transport of trash and that required by facilities related to water supplies and sewers.

2. Formation of a Transportation System that Limits Carbon Dioxide Emissions

In response to increasing transportation demands, in order to control emissions of carbon dioxide while maintaining the smooth transfer of people and objects, we will work toward reducing emissions in each transportation facility as a unit. In addition, while working toward cooperation among freight transport facilities, we will review measures that will lighten the demand for automobile transportation, and in working toward the formation of a transportation system that limits carbon dioxide emissions, we will implement these measures gradually beginning with the most practicable.

—(1) While proceeding even further with improving fuel efficiency by reducing automobile weight and running

resistance, we will lower carbon dioxide emissions on a car-by-car basis by actively promoting the development and introduction of hybrid engines, ultra-lean burning systems, and the utilization of regenerative energy technology. In addition, with respect to rail, ship and air transportation, we will seek increased energy efficiency through technical improvements and encourage the introduction of items with good energy efficiency.

—(2) We will promote the use of energy that limits carbon dioxide emissions, mainly in the automotive field, and actively promote the introduction of automobiles that produce little pollution, such as electric automobiles.

—(3) With respect to freight transport, we will actively work toward a modal shift (inducement toward rail transport and domestic shipping) for mainline transport between mid- and long-distance shipping locations. With truck transport, we will also work toward increasing freight transport efficiency by promoting the use of commercial trucks, encouraging transport pools, and implementing information systems and the consolidation of intensive shipping sites.

—(4) With respect to passenger transport, we will promote the consolidation of public transportation facilities such as rail, bus, and new transportation systems, and we will promote the use of public transportation systems, particularly in major urban areas, by implementing service improvements in these transportation facilities.

—(5) In order to reduce carbon dioxide emissions from running vehicles by alleviating automobile traffic jams and ensuring efficient, smooth traffic flow, we will improve the road system with overpass/underpass intersections, improved intersections, bypasses, loop highways, etc., and improve and update traffic control systems.

3. Formation of an Industrial Structure that Limits Carbon Dioxide Emissions

We will actively promote the efficient utilization of energy and the introduction of energy sources that emit little or no carbon dioxide in the manufacturing industry, in the agriculture, forestry and fisheries industry, and in the construction industry.

—(1) In manufacturing we will increase fuel-burning efficiency, promote the dissemination of various types of energy-saving manufacturing equipment, and promote the introduction of processes that contribute to energy saving. Therefore, we will encourage technical developments such as fusion-reduction iron making, and direct caustification techniques, and work toward their implementation. We will also promote the utilization of thermal exhaust among plants within the same industrial complexes.

—(2) In the agriculture, forestry and fishing industries, we will work toward improvements for efficient energy utilization in agricultural machinery, fishing boats, and the like. We will also promote the use of natural energy and biomass energy for use in heating items such as protected horticulture, and in drying items such as grain.

—(3) In the construction industry, we will work toward improvements in efficient energy utilization in construction machinery and promote the use of blast furnace cement.

4. Formation of an Energy Supply Structure that Limits Carbon Dioxide Emissions

In electric power generation and in the energy conversion businesses, such as urban gas manufacturing, we will promote an increase in energy conversion efficiency and the introduction of energy sources that emit little or no carbon dioxide.

—(1) In the field of electric power generation:

—(1a) We will promote the development and use of atomic energy, under the premise of guaranteed safety, as a type of energy that does not emit carbon dioxide. In addition, we will also promote the use of water power and geothermal power, continue technological development, and proceed with the combined use of solar and wind power. We will also promote the use of natural gas, which is a fuel that emits little carbon dioxide.

—(1b) In order to improve electrical power generation efficiency, we will promote the development and introduction of combined cycle power generation and ultra-ultra critical pressure plants.

—(1c) We will actively promote the introduction of diversified electrical energy resources such as fuel cells and solar cells.

—(2) We will promote the use of liquified natural gas in cities and consolidate a foundation for the introduction of natural gas.

—(3) In order to even out the load on electricity, we will promote reduction of demand during peak hours and the storage of energy through the establishment of power load concentration regulating technology, and we will promote the dissemination of gas cooling.

5. Realization of a Lifestyle that Limits Carbon Dioxide Emissions

In order to create a lifestyle in the home that limits carbon dioxide emissions, we will work toward the consolidation of social systems and the enrichment of environmental education.

—(1) We will promote the recycling of paper, cans and bottles, and promote the creation of a system for the development and dissemination of products that are easy to recycle, and of recycled products.

- (2) We will reconsider the status of items that consume large amounts of energy such as excessive packaging and vending machines, and the status of distribution services, such as the onslaught of direct mail advertising.
- (3) We will work toward the promotion and dissemination of products that limit carbon dioxide emissions through the use of an environmental seal of approval.
- (4) We will study the introduction of daylight savings time and work toward shortening working hours through the promotion of simultaneous summer vacations.
- (5) In home and office we will promote the proper temperature settings for air conditioners and heaters, the introduction of energy regulation systems, and the use of highly energy efficient home appliances and office automation equipment.

II. Measures for the Control of Emissions of Methane and Other Greenhouse Gases

Concerning greenhouse gases other than carbon dioxide such as methane, which is increasing in concentration in the atmosphere, nitrous oxide, and tropospheric ozone, we will implement the following overall countermeasures.

Moreover, the necessary measures that have already been established against freons and which are based on international agreements, protocols and domestic laws with the purpose of protecting the ozone layer in the stratosphere will be continued independently of this plan, and we will strive to implement measures based on these regulations.

1. Methane Countermeasures

Based on the fact that previous environmental protection measures and future measures for regulating the emissions of carbon dioxide contribute to the regulation of methane, we will promote these measures even more strongly. In addition, we will work toward reviewing new measures and gradually implement measures as technical development proceeds.

- (1) Measures for the Management of Solid Waste
 - (1a) We will work toward the utmost in resource recovery from general solid waste, and promote reduction in its volume.
 - (1b) We will work toward large scale reduction in methane emissions by striving to burn all burnable trash on which no intermediate treatment is conducted, such as by resource recovery or by other methods, and by eliminating the burying of unprocessed organic materials in landfills. In addition, in implementing these measures, we will strive for effective utilization of the heat given off by incineration.

- (1c) We will promote the utilization as resources, reuse, and appropriate disposal of industrial wastes such as sludge and wood scraps.

- (1d) In the event organic materials are buried in landfills, we will not only promote quasi-aerotropic burying that emits little methane, but we will also work toward methane collection, disposal, and utilization.

—(2) Measures for Agriculture

- (2a) In the case of rice paddies, we will continue to study the actual state of emission, and based on the fact that improvements in water management, such as drainage improvement, and proper management of applied organic materials is thought to contribute to the reduction of methane emissions, we will proceed to review these measures.

- (2b) For livestock, we will promote measures mainly concerned with the aerobic fermentation of livestock manure and attempt to grasp the actual state of emissions from livestock.

—(3) Measures for the Production and Use of Energy

- (3a) In the mining of coal, we will continue to proceed in the future with the removal, collection and utilization of gas, which has been conducted as a safety measure.

- (3b) In the gas supply business, we will continue to proceed in the future with emission regulating measures to prevent gas leaks, etc.

- (3c) With respect to the burning of fuels in the transportation field, we will continue to promote measures for the beneficial use of energy, study the actual amount of emissions, and proceed to review measures, including technical possibilities, for regulating emissions such as by the elimination of items if the need arises.

2. Measures for Nitrous Oxide

Concerning the emission from land treated with nitrogen fertilizers, we will continue to study the actual state of emissions, and proceed with the development of management technology, which contributes to efficiency in the application of nitrogen, and to study emission control measures such as the development and use of slow-release fertilizers. In addition, concerning emissions from the burning of fossil fuels, we will clarify the generation and emission mechanisms, study the amount of emissions quantitatively, and proceed with research and technical development aimed at introducing emission control measures.

3. Additional Measures

We will study the contribution to global warming of carbon monoxide, which increases the atmospheric concentration of methane and tropospheric ozone, hydrocarbons other than methane, nitrogen oxides (NO and NO₂) and strive to implement the measures we have previously promoted.

III. Measures for Carbon Dioxide Absorbing Resources (Forests and Greenery)

In order to work toward proper maintenance and expansion of forests and urban greenery, which are carbon dioxide absorbing resources, we will continue to consider both the preservation of the ecological diversity of forests and their sustainable utilization, study both their size and type, and implement comprehensive, planned conservation of the greenery in forests and urban areas.

We will also work toward proper utilization of timber resources at the same time.

1. Conservation of Greenery in Domestic Forests and Urban Areas

—(1) Proper Conservation of Forests

—(1a) We will continue to ensure the diversity that ranges from highly natural forests to those remaining in urban districts. We will not only systematically conserve them, but implement sustainable management of forests.

—(1b) We will strive for consolidation of forest industry systems and increase the standards of control on forests by implementing proper tending, such as thinning. In addition, through putting an end to clear cutting, and implementing extended cutting cycles, and management of multi-layered forests, natural breeding forests, and natural regeneration forests we will promote maintenance of a variety of forests and sustainable forest management.

—(1c) We will support various private movements concerned with forest preservation, starting with the National Trust Movement, and we will promote local forest conservation and maintenance in rural and suburban areas through the participation of the district inhabitants.

—(1d) We will promote forest conservation through the participation and contributions of funds by the citizenry.

—(1e) We will study the effect on forests of environmental pollutants such as acid rain, and promote appropriate countermeasures.

—(2) Conservation and Creation of Urban Greenery

—(2a) We will promote the greening of public facilities, factories and business offices.

—(2b) In order to link the green areas and woods within cities or those that surround them so that we can assure wide-ranging and continuous green areas, we will implement comprehensive urban greening by working toward the conservation of urban parks and urban green areas and by promoting the greening of residential areas and building rooftops.

—(2c) We will promote greening through the participation and contributions of funds by the citizenry.

2. Proper Utilization of Timber Resources

—(1) Proper Trading in Tropical Timber

We will work toward proper trading in tropical timber by making an active contribution to the activities of the International Tropical Timber Organization (ITTO), which aims for the sustainable management of tropical forests.

—(2) Beneficial Utilization of Timber Resources

We will work toward the promotion of the utilization of cut timber. We will also promote durable wood products, reuse of wood products, and recycled paper, and implement overall beneficial utilization of resources by reducing the use of throw-away items.

IV. Promotion of Scientific Research, Observations and Monitoring

We will promote comprehensive research, observations and monitoring concerning global warming based on "The Comprehensive Promotion of Research, Observations, and Monitoring, as well as Technical Development Concerning Preservation of the Earth's Environment" (Agreement by the Prime Minister's Council for Preservation of the Earth's Environment), and the "Basic R&D Plan Concerning Earth Science Technology." In doing so, we will actively participate in international projects including international cooperative research plans such as the International Geosphere Biosphere Plan (IGBP) and the World Climate Research Plan, and we will work toward research exchanges.

More specifically, Japan will proceed with research, observations and monitoring with an emphasis on Asia and the Pacific Ocean Area in cooperation with researchers from this area. Therefore, we will work toward a complete research system with sites for research, observation and monitoring.

In addition, we will strive for common use of these results on a worldwide scale through making them into data bases and networks.

In addition, we will train researchers and technicians in a wide range of fields related to research on global warming.

1. Scientific Research

—(1) Clarification of Mechanisms and Future Projections

—(1a) In order to increase technology for understanding the mechanisms of global warming and for making projections, we will attempt to clarify the effect on clouds, the effect on oceans including the mutual actions of the atmosphere and the oceans, the effect on snow and ice, the effect on ecological systems, and ancient climates. For example, we will strive to implement research concerning the radiation process of clouds, changes in the ocean including deep layers, and polar ice sheets.

—(1b) We will study the major factors that influence climate formation and climatic change through even better models, and we will strive for a higher level in climatic models, by attempting to create models with finer resolution.

—(1c) In order to contribute to the realization of increased forecast precision and comprehensive measures for reducing greenhouse gases, we will study the sources of generation, specify sources of absorption, and quantitatively measure the generation and absorption of the various greenhouse gases including carbon dioxide, methane, and nitrous oxide. For example, we will strive to promote research concerned with understanding the carbon dioxide absorbing capability of the oceans and research on the emissions of methane in high latitude areas such as Siberia.

—(2) Evaluation of Effects

In order to make a detailed evaluation of the various effects of warming, such as the effects global warming has on the ecological system, health, water resources, and social and economic life, as well as damage to coastal areas, we will work toward the development of a model for evaluating these effects. In addition, we will strive to establish methods for economic evaluation of the effects and for calculating environmental resources.

—(3) Proposal and Evaluation of Countermeasures

We will strive to establish methods for evaluating the techniques of countermeasures taken against global warming and methods for evaluating the measures in economic terms. In addition, we will promote research for creating environment-preserving social systems and research concerning ways of conducting our daily lives in harmony with the global environment.

—(4) Comprehensive Global Warming Research in Asia and the Pacific Area

We will strongly promote research concerning the effects of global warming and countermeasures in Asia and the Pacific Area. Therefore, we will work toward increased precision in forecasting changes in area climate by clarifying the mechanisms of global warming. Moreover, as our nation continues to play a central role in Asia and the Pacific Area, we will promote comprehensive research on global warming in that area through combined research with various nations in Asia and the Pacific Area to specify the emission and absorption

amounts of greenhouse gases, to evaluate the effects of global warming, and to propose and evaluate countermeasures.

2. Observation and Monitoring

In order to promote understanding of and research on the global warming phenomenon and its effects, we will implement planned monitoring of changes in greenhouse gases, greenhouse related gases, the climate, the oceans, and the ecosystem through the use of satellites, aircraft, ships, and land-based observation and monitoring facilities, and we will also strive to disseminate this data from observation and monitoring. We will also proceed with R&D on higher level observation and monitoring techniques.

For example, with respect to monitoring greenhouse gases, and weather and ocean phenomena, we will promote R&D on sensor observation technology and data processing technology based on the fact that satellite observation and monitoring is so important, and we will also contribute to worldwide observation and monitoring as part of an international network.

V. Technological Development and its Dissemination

Our nation possesses some of the best energy-saving techniques in the world and, in addition to working for further dissemination of these techniques, we will strive to promote development of even better energy-saving technology, new energy technology, and carbon dioxide absorption and fixation technology based on the various, above-mentioned plans, and we will work toward building a social system that promotes the dissemination of technology.

1. Technology for Controlling Greenhouse Gas Emissions

—(1) In order to control emissions of greenhouse gases, we will promote the development and use of atomic energy under the premise that safety will be guaranteed. In addition, we will promote the development and use of new and alternative energies that emit little or no carbon dioxide such as natural gas and natural energies including solar, wind, and wave power.

—(2) We will develop high efficiency turbines and manufacturing techniques that limit carbon dioxide emissions including those that utilize energy efficiently, such as fuel cells, and those that utilize biological functions. In addition we will proceed with the development of technology for energy and resource savings in homes and everyday appliances, with the utilization of untapped energy in sewers, rivers, the sea and solid waste disposal, with the development of technology for the high-efficiency utilization of energy, and with the development of systems and techniques to improve energy efficiency in the field of transportation, such as with automobiles.

- (3) We will promote the development and dissemination of techniques for the regeneration and utilization of solid waste.

2. Technology for Absorbing and Fixing Greenhouse Gases

We will develop carbon dioxide absorption techniques through the use of absorbents, adsorbents and separation membranes, and we will develop techniques for long-term fixation and reuse of carbon dioxide absorbed by artificial photosynthesis.

We will also develop techniques for increasing the biological capability of carbon dioxide fixation by using algae, biotechnology, and biomasses.

In addition, we will develop techniques for the conservation of forests as sources of carbon dioxide absorption, and for stopping the spread of deserts. We will also develop techniques for the utilization of resources to replace pulp in order to contribute to the conservation of forests.

3. Technology for Adaptation to Warming

In preparing for changes in temperature, sunshine and falling water tables due to future warming, we will strive to develop techniques in agriculture, forestry and fisheries including the development of breeds adapted to the environment, to develop techniques for flood control and water usage in response to changes in the falling water table pattern, to develop techniques to counter rising sea levels, including the preservation of seacoasts and rivers, and the reconstruction of cities, and to develop techniques for the preservation of plant and wild animal species in response to changes in climate.

VI. Dissemination and Enlightenment

We will obtain the consent and cooperation of the citizenry over a wide range of fields and at many levels in the implementation of the measures against global warming. We will also work toward widespread understanding of the action plan and the dissemination of accurate information based on the most recent scientific knowledge concerning the problem of global warming in order to promote participation of business people and the citizenry from the bottom up in preserving the earth's environment. We will also strive to promote environmental education on a wide scale, and aid and support autonomous groups.

- (1) We will work toward dissemination and enlightenment by making use of various media such as television and through events such as Environment Week, and we will work toward complete environmental education by sponsoring lectures on environmental protection.
- (2) In the schools, we will work toward even greater environmental education in the curriculum by expanding the lessons about world environmental problems, experiences with nature, etc., and we will

work toward increased instructional capability of teachers in environmental education.

- (3) We will work toward consolidation of citizen movements for energy and resource conservation, and the movements and organizations for the promotion of greening. We will also aid and support various world environmental conservation movements and organizations.
- (4) We will create various manuals and guidelines announcing the results of research and compiling actual examples of world environmental conservation activities.

VII. Promotion of International Cooperation

In order to give strong support to measures against global warming in the developing nations, we must continue to participate in the international effort concerning aid to developing nations, such as by the review in the World Bank concerning world environmental facilities, and we will strive to promote international cooperation for doing even more to aid governmental development. In addition, we will actively promote cooperation among industrially advanced nations in the fields of research and technical development.

More specifically, in this case we will actively promote the transfer to developing nations of technology that will contribute to the prevention of global warming such as highly energy-efficient manufacturing equipment and techniques, and technology for new and regenerative energy, and we will aid in the conservation and creation of carbon dioxide absorbing resources, mainly the tropical forests, which comprise about 40% of the world's forests.

1. Comprehensive Support for Measures to Prevent Global Warming

We will actively provide comprehensive support by supplying information, making observations, monitoring, evaluating effects, and planning and implementing countermeasure strategies concerning scientific knowledge of global warming. We will also provide comprehensive support for the inclusion of developing nations in countermeasures against global warming such as improving their capability to deal with environmental problems.

2. Promotion of the Transfer of Technology to Contribute to the Prevention of Global Warming

- (1) We will promote the active transfer of technology that can contribute to the prevention of global warming, such as highly energy-efficient manufacturing equipment and technology, transportation facilities, and new and regenerative energy technology, to developing nations where energy efficiency is low, and the emissions of carbon dioxide are expected to increase rapidly accompanying future economic expansion.

- (2) We will promote efforts on a worldwide scale by inviting to Japan the "UNEP World Environmental Preservation Technology Center" (proposed name) whose purpose is to provide information, consulting and seminars to developing nations on techniques for preserving the environment and to work toward the transfer of technology, and by working toward affiliation with its related organizations.

3. Support for Preservation and Creation of Carbon Dioxide Absorbing Resources such as Tropical Forests

- (1) We will strengthen our support so that the ITTO can be active as a world forest fund that can truly carry out its established goals, and we will strive to promote internationally the Tropical Forestry Action Plan (TFAP) of the United Nations Food and Agriculture Organization (FAO). In addition, we will continue to work toward international cooperation and make appropriate responses so that the Tropical Forest Action Plan will be improved and strengthened in a form that places even greater emphasis on the preservation of forests and the ecosystem, and so that the ITTO Action Plan will be strengthened in a way that emphasizes sustainable forest maintenance and improves the workings of the marketplace.
- (2) In accordance with the concept of managing a green earth, we will continue to respect the sovereignty of nations that possess tropical forests, and we will provide support for sustainable forest management, reforestation, and preservation of the ecosystem. In addition, we will strive for the enactment of an international forest charter and through its promotion actively contribute to the creation of an international framework concerning forests.
- (3) Concerning support in the monitoring of tropical forests and creation of an information network, we will actively engage in the preservation, and creation of forests, particularly tropical forests, and continue to cooperate in research.
- (4) We will strive to support tropical forest preservation programs appropriate to the special features of the areas in countries that have tropical forests, such as Brazil.
- (5) In order to control loss of tropical forests caused by the burning of fields to clear new land, we will provide support to improve productivity on existing agricultural land.
- (6) We will work toward affiliations with international organization and aid in comprehensive protection measures for temperate forests in the same way as for tropical forests.
- (7) The effects of environmental pollution such as acid rain are also important in the loss of the world's forests, and we will work toward the transfer of anti-pollution technology as a countermeasure against environmental pollution.

- (8) We will continue to work toward affiliations with international organizations. We will also support action plan policy decisions for each area to prevent the spread of deserts, and we will promote international cooperation to prevent the spread of deserts such as cooperative research that contributes to that goal.

4. Promotion of Cooperation in Research and Development of Proper Technology

- (1) We will actively promote cooperation in research among industrially advanced nations in technological developments, mainly those innovative technical developments in research, observation and monitoring, carbon dioxide fixation, and effective utilization technology concerned with global warming.
- (2) The introduction of proper technology to developing nations is necessary based on the techniques, personnel and economic strength, and we will strive to develop and disseminate applicable technology for developing nations in accordance with the state of affairs in each country. In doing so, we will actively promote cooperation in research and cooperation with the research organizations of the developing nations.

5. Promotion of International Cooperation by the Private Sector

We will support activities to transfer technology by the private sector because companies in the private sector have accumulated a large number of environmental protection techniques through our nation's past efforts in preventing pollution. In addition, we will strive to support private sector activities such as sustainable forest management and reforestation measures to conserve and construct forests, and debt/nature-protection swap transactions.

6. Considerations on the Prevention of Global Warming in International Cooperation Projects

When necessary, we will consider the implementation of international cooperation projects from the standpoint of preventing global warming, such as their use of technology to limit carbon dioxide emissions, in order that development in developing nations can proceed in a form that is compatible with the prevention of global warming. In addition, because the preservation of tropical forests, including the surrounding areas, is inseparable from the actualization of sustainable development, we will fully consider the implementation of international cooperation projects in tropical areas, when necessary, from the comprehensive standpoint of environment, society, economics, and culture.

Part 6. Implementation of the Action Plan

The government will strive for the smooth, effective implementation of the Action Plan.

- (1) Based on international discussion and studies, the various ministries and government agencies will continue to review necessary government measures and propose necessary steps in order to bring about the items determined in "Part 5. Measures To Be Taken."
- (2) Each year the Prime Minister's Council for Preservation of the Global Environment will receive reports not only on carbon dioxide emissions, but also on the implementation status of these countermeasures. In addition, it will review implementation of the Action Plan based on these reports when necessary.
- (3) It is hoped that local public organizations will be included whenever possible in accordance with the

Action Plan. In order to gain the necessary cooperation of local public organizations, the national government will provide information and supply basic guidance for the inclusion of local public organizations in countermeasures against global warming, and will adopt supportive measures for local public organizations, such as setting up conditions for countermeasure implementation.

- (4) The various ministries and government agencies will propose necessary support measures for providing information, in addition to working toward complete public awareness of the Action Plan, through the officers of the organizations concerned, so that business people can be actively included in accordance with the Action Plan.

Color Liquid Crystal Displays, Polymers

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 KOEN YOSHI in Japanese 29 Jan 91 pp 6-17

[Article by Yasumasa Takeuchi, Electronics Division
 Development Team, Japan Synthetic Rubber Ltd.]

[Text]

1. Introduction

The color liquid crystal display (LCD) is the most promising candidate as the flat-panel display (FPD) to replace the CRT and will play a major role in the LCD industry, which is expected to develop into a several-trillion-yen industry in the future. Although active research and development toward achieving large-screen, high-definition and low-cost color LCD's has been carried out, it does not seem to be an easy task. In realizing such color LCD's, the role of polymers is important. This paper discusses the relationship between color LCD's and polymers, as well as the role of polymers.

2. Summary of LCD Industry Development

An electronic display device utilizing electro-optical effects was first commercialized in 1973 in watches and electronic calculators. Since then, the research and development of LCD's has been accelerated due to its light, thin and small characteristics, as well as its energy efficiency, with the LCD market scale steadily increasing to ¥50 billion in 10 years. During these 10 years, the LCD gradually increased its display capacity and expanded its uses to include game machines, measuring instruments, household electric appliances and automotive equipment.

In 1984, a pocket-type, full-color LCD television, designating the first year of the LCD TV era, was marketed and gave a new outlook for the LCD. In 1985, the single-matrix STN LCD was marketed in which the angle of visibility and contrast, which had represented problems with the former LCD models, had been greatly improved. In 1988, a VTR combined with a three-inch full-color active matrix (AM) LCD was commercialized. Such new products became topics of conversation. With the size of the AM LCD screen increasing annually, at the international Society of Information Display (SID) meeting in 1989, a 14-inch full-color AM LCD model utilizing a TFT (thin film transistor) was introduced and compared with a CRT model, impressing the participants with the increasing possibility that the full-color AM LCD would replace the CRT.

The LCD industry had grown to the ¥100 billion level in 1988 and the ¥200 billion level in 1990 with the steady growth shown by the STN LCD, utilized in OA equipment, and the LCD utilized in AV equipment.

3. Scenario for Development of LCD Industry

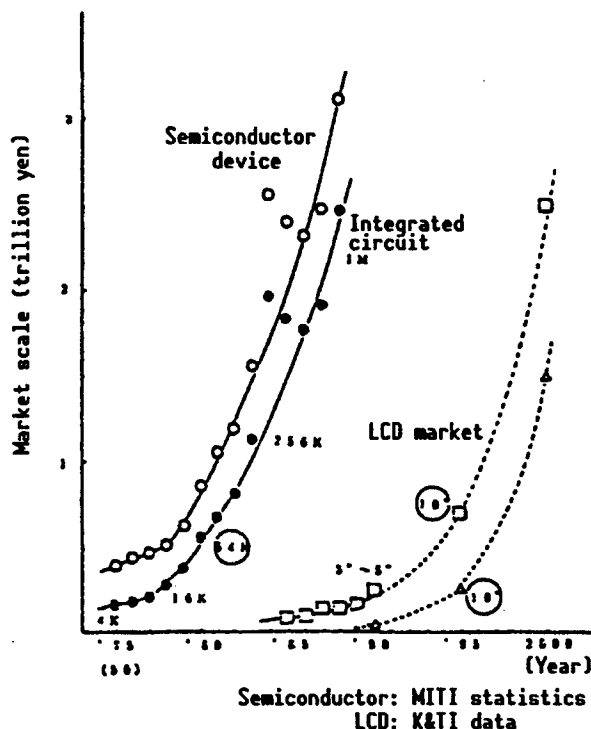


Figure 1. Growth Curve for LCD Industry (estimate)

It is a dominant view that the scale of the LCD industry will reach ¥1 trillion in 1995 and ¥2 trillion in the year 2000.¹ The growth curve for the LCD industry is analogous to that for the semiconductor industry (Figure 1). The scale of the current LCD industry is ¥200 billion, which corresponds to the semiconductor industry situation in 1975 when its scale reached ¥200 billion. At that time, the 4K DRAM was produced in the semiconductor industry and, due to the high possibility of demand for the production of high density DRAM for use in future computers, active investment took place. In the LCD industry, the full-color AM LCD is considered to represent the most likely candidate for the displays utilized in future personal computers (PC's) as well as in high-definition monitors for home use and, with these high expectations, investment has become active.

One of the forces behind the development of the LCD industry is the PC display represented by the laptop, desktop and notebook types² (Figure 2). The number of PC units equipped with color LCD's is expected to increase drastically around 1991-1992 (Figure 3). PC software is expected to become a multi-window system represented by Microsoft's Windows 3.0. Then, high-definition, mobile images and color will be required for display performance and, therefore, the demand for the full-color AM LCD utilizing TFT, among other color LCD's, will increase. The current notebook type of word processor will be made smaller and replaced by the so-called "palm-top" type. It is believed that a black and white display, primarily used for character and graphic data, will be sufficient for such a small type.

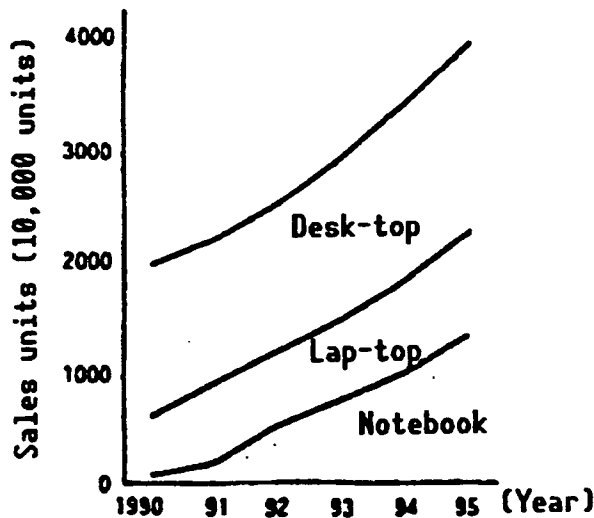


Figure 2. International Personal Computer Market
(Source: Nikkei BP Sha)

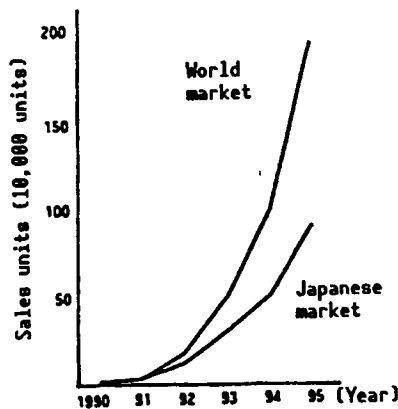


Figure 3. Japanese and International Markets for Personal Computers Equipped with Color Liquid Crystal Display (The international market is 10 times that of Japanese market) (Source: Nikkei BP Sha)

Another force helping to develop the LCD industry is the AV equipment display. Wall televisions and the direct viewing high-definition receiver require displays exceeding 20 inches, which are expected to be produced after the year 2000. The full-color AM LCD between 5 and 14 inches will be developed for automobile televisions and combination AV equipment, such as VTR's equipped with televisions (Figure 4). For high definition receivers, the projection-type LCD will mainly be used until the direct viewing type is completed (Figure 5).

The color AM LCD, which supports the scenario for LCD development, includes not only a large size, but also a small one such as that for a view finder for a video camera with an internal VTR (Figure 6).

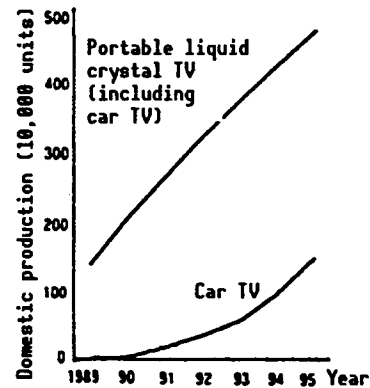


Figure 4. Market for Automobile-Equipped TV
(Source: Nikkei BP Sha)

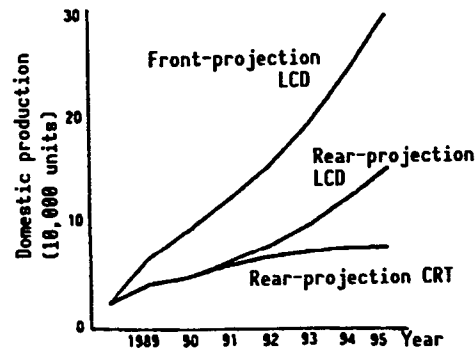


Figure 5. Market for Projection-Type Display
(Source: Nikkei BP Sha)

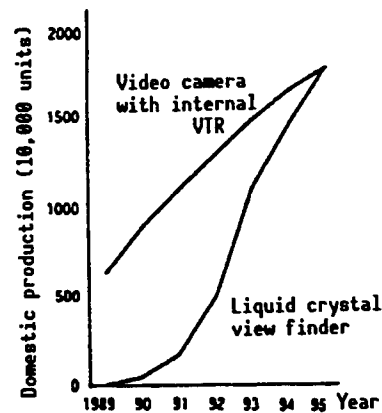


Figure 6. Production of Video Camera with Internal VTR and Liquid Crystal View Finder
(Source: Nikkei BP Sha)

The primary force behind the LCD industry development, from the viewpoint of LCD modes, will initially be STN LCD, then, after 1995, the AM LCD, represented by the TFT LCD (Table 1).

Table 1. Trends of LCD Types

LCD Type	1990	1995	2000
AM	320	2,500	15,000
STN	1,180	3,500	8,500
TN	950	1,000	1,500
Total (¥ 100 million)	2,450	7,000	25,000

Source: K & TI (FDP Seminar, Kansai, 1990)

In order to achieve the above scenario, the color AM LCD must be manufactured at low cost or, in other words, at a high yield rate. The role played by polymers in realizing this is important.

4. LCD Structure

The principle of the LCD is a light switch which utilizes the liquid crystal movement corresponding to electric signals and the change in the transmissivity of the polarizing light following such movements illustrated in Figure 7 and Figure 8 [not reproduced]. By dividing an image into fine dots and moving the liquid crystal of the dots with electric signals, light and shade is created and the image can be reproduced.

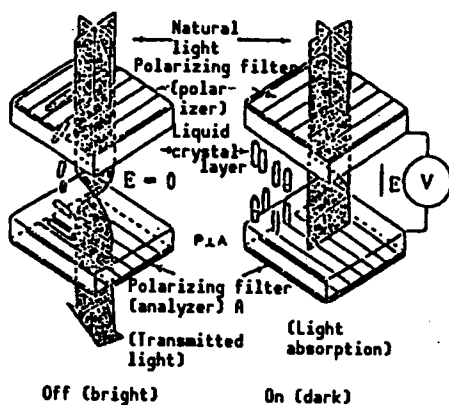


Figure 7. TN (twisted nematic) Type Display Principle

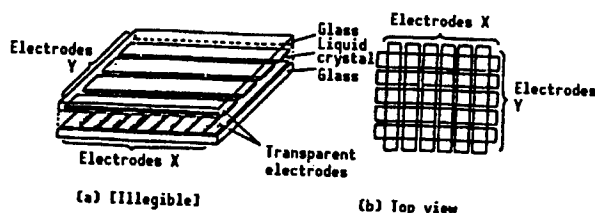


Figure 9. Structure of Large-Scale Simple Matrix System: Two sets of transparent electrodes are arranged to cross at right angles, with the liquid crystal, covered by glass, in the middle.

In the simple matrix system, two sheets of transparent electrodes are arranged to cross, at right angles, at a liquid crystal driving point, as shown in Figure 9. The active matrix system has a structure in which a TFT or diode corresponds to each driving point, as shown in Figure 10 [not reproduced].

The basic LCD structure is illustrated in Figure 11.

5. Color LCD

The LCD consists of display components which utilize transmitted light to form images. There are three major methods of forming images with the color LCD:

- (1) A color image is formed by light transmitted from the color filter.
- (2) A color image is formed by light transmitted from the polarizer.
- (3) Colors are mixed into the liquid crystal and an image is formed by colored light.

The projection-type LCD can either use the projection lenses to project the color image formed by the above methods on the screen or use the LCD as an optical shutter for the three primary colors, forming color images by optical mixing. The optical shutter in the latter case is the TFT LCD.

The full-color AM LCD, the main character in the scenario for LCD industry development, utilizes the color filter, while the projection-type LCD uses optical mixing of the three major colors.

6. Material Components for Color LCD

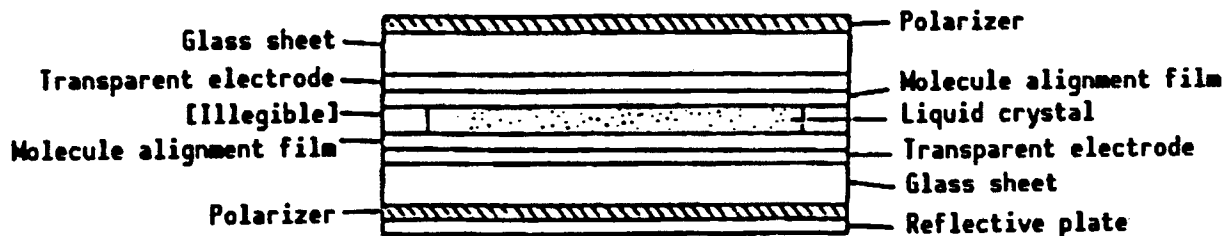


Figure 11. Cross-Sectional View of Reflection-type TN LCD

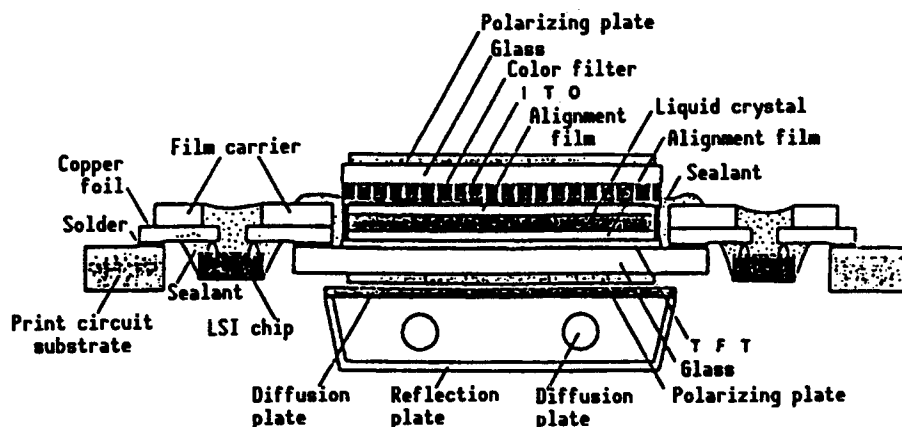


Figure 12. Conceptual Plan for Color LCD

The basic configuration of the full-color AM LCD is illustrated in Figure 12. The major organic materials used to produce color AM LCD panels, together with problems to be solved, are listed in Table 2. The phase difference plate is necessary for the color STN LCD, but not for the full-color AM LCD. An outline of the production process for the color TFT LCD, which is the main component of the color AM LCD, and problems to be resolved at each stage are presented in Table 3.

7. Polymers Used in Color LCD Panel Production

7.1 Polarizing Plate^{3,4}

The polarizing plate is a device that transmits light solely from the plane of polarization and plays the role of transmitting and intercepting light in the LCD and, as long as the liquid crystal is the twist nematic (TN) type, is an indispensable part of the LCD. The basic structure of the polarizing plate is illustrated in Figure 13. Some may also have UV cut film affixed on them.

Materials for polarizers are either of the PVA-iodine group or the PVA- color group. The protection layer is either of TAC (triacetyl cellulose) or an acrylic-TAC double layer.

Current problems, such as improvements in weather, heat and moisture resistance, seem rather difficult to solve using conventional polymers. In order to resolve the problems, it is necessary to develop new transparent polymers and new polar elements⁴ superior to the those of the iodine and color groups.

7.2 Phase Difference Plate³

A phase difference plate, designed by utilizing double refraction effects, is used to remove the interference color caused by the STN LCD. The phase difference plate, by thickness, controls the double refraction produced when the high polymer film is stretched along one axis (phase difference = double refraction index x film thickness). Polymers used for phase difference plates

Table 2. Main Organic Materials for Color LCD Panel

Material	Problems to be solved
1. Polarizing plate	Weather, heat and moisture resistance
2. Phase difference plate	Uniformity
3. Alignment film	Stability (tilt angle), low temperature process
4. Color filter	Uniformity: Color loss, color density, measurement, form Colors, density, thickness
5. Liquid crystal	
6. Sealant	Low-temperature curing
7. Spacers	Coloring (projection type), agglomeration, movement (tackiness), uniformity
8. Resist	Sensitivity, application performance

■ : Important functional materials

Table 3. Outline of Color TFT LCD Manufacturing Process

Manufacturing process outline	Processing method	Problems to be solved
<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 2px; width: 150px; text-align: center;">TFT system</div> <div style="border: 1px solid black; padding: 2px; width: 150px; text-align: center;">Color filter production</div> </div> <p>Glass</p> <p>Electrode metal production</p> <p>TFT production (Si/SiN)</p> <p>Transparent electrode production (ITO)</p> <p>Protection film production (SiN)</p> <p>Alignment film (Optmer AL)</p> <p>Rubbing</p> <p>Lamination</p> <p>Liquid crystal injection</p> <p>LCD panel inspection</p> <p>Driver mounting</p> <p>Modularization</p> <p>Final inspection</p> <p style="border: 1px solid black; padding: 2px; text-align: center;">Delivery</p>	<p>Photolithography, coloring</p> <p>Spin coating</p> <p>Sputter, photolithography</p> <p>Plasma CVD, photolithography</p> <p>Inspection/correction</p> <p>Sputter, photolithography</p> <p>Plasma CVD, photolithography</p> <p>Offset printing</p> <p>Rubbing</p> <p>Lamination</p> <p>Vacuum injection</p> <p>LCD tester, inspection/correction</p> <p>TAB mounting</p> <p>Controller mounting</p> <p>Tester, needing</p>	<p>Flatness, purity</p> <p>Heat and light resistance, uniformity</p> <p>Flatness</p> <p>Low resistance, high precision</p> <p>Large area, pinhole elimination, high throughput</p> <p>High-speed automatic recognition</p> <p>Low resistance</p> <p>Large area, pinhole elimination, high throughput</p> <p>Low-temperature processing, stability</p> <p>Static prevention</p> <p>Precise lamination, heat, light, and moisture resistance (polarizing plate)</p> <p>Heat and light resistance, high-speed response (liquid crystal)</p> <p>High-speed automatic recognition, redundant design and correction</p> <p>High density</p> <p>Thin form, low power</p> <p>High-speed automatic recognition</p>

include PVA, polycarbonate, acrylic and polyester materials. A problem to be resolved involves achieving optical uniformity. The smoothness of the film surface is expected to be under $\pm 0.3 \mu\text{m}$, and a highly accurate film processing technology is required.

7.3 Alignment Film^{5,6}

Alignment film is thin film that arranges crystal molecules regularly and is an indispensable material in LCD

production. For the color AM LCD, the film is placed on the TFT and on the color filter with transparent electrodes. Thin film made of a heat-resistant polymer with high T_g was sufficient until the color LCD, utilizing a color filter, was developed. The materials for forming such thin polymeric film were limited during the 1970's, and polyimide was used as the alignment films since polyimide was a heat-resistant polymer, appropriate for coating and printing, that could be made into film by applying a polyamic acid solution and baking at high

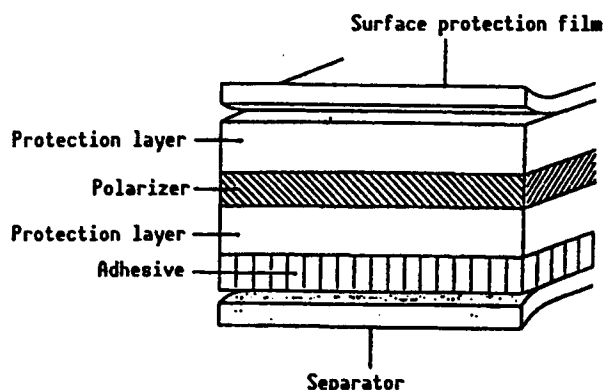


Figure 13. Structure of Polarizing Plate

temperatures⁷. For color AM LCD development, alignment film appropriate for low-temperature processing so that the color filter characteristics could be maintained was required and, regarding the performance characteristics of the TFT LCD, alignment film with higher voltage retention and higher time constants was required. Japan Synthetic Rubber, Ltd., responding to these demands, developed soluble polyimide and marketed "Optmer AL" (trademark), an alignment film for low-temperature processing, which supported the development and merchandizing of the color AM LCD (Figure 14.)

In order to improve the display quality, it is necessary to be able to select the tilt angle suitable for the device and emit the charge accumulated in the device. It is required

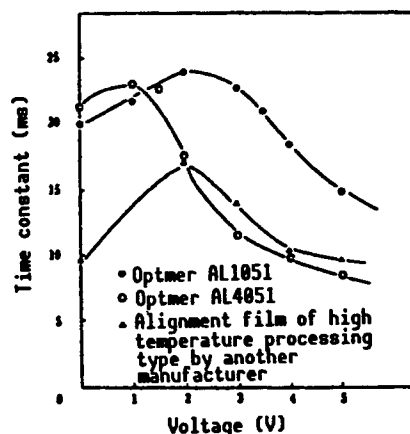


Figure 14. Time Constant of Optmer AL

that reliable alignment film be developed for the low-temperature process. It is also necessary that alignment film be developed whose applications can readily correspond to increases in device size.

7.4 Color Filter^{9,10}

Various methods of producing color filters have been developed (Table 4) [not reproduced]. The color filters that can currently be mass-produced are indicated in Table 5¹⁰. The color filter appropriate for the color TFT LCD, the main character in the LCD industry development scenario, can be colored by colors or pigments and, regarding its manufacturing process, photolithography can be singled out due to its higher precision.

Table 5. Characteristics of Various Colored Filters [additional explanation illegible in original text]

Type		Coloring Method	Color Dispersion Method	Printing Method	Pigment Dispersion Method	[illegible]
Thickness (μm)		1.0-2.5	1.0-2.5	2.0-3.5	0.8-2.0	1.5-2.5
Spectral characteristics		Excellent	Good	Good	Good	Good
Resolution (μm)		10-20	10-20	70-100	20-30	10-20
Flatness		Good	Good	Fair	Good	Excellent
Heat resistance (°C/hour)		180	200	250	under 250	250
Light resistance		Fair	Fair	Good	Good	Good
Chemical resistance		Fair	Good	Good	Good	Good
Coloring layer	Resin	Acrylic resin, gelatin	Polyimide resin	Epoxy resin	Acrylic resin, Sbg, PVA, etc.	Acrylic resin, epoxy resin
	Color element	Colors	Colors	Pigments	Pigments	Pigments
Characteristics	Advantages	Precision, spectral adjustment	Precision	Resistance (light, heat)	Resistance (light, heat)	Resistance (light, heat), smoothness
	Disadvantages	Resistance	Resistance	Precision, smoothness	Enzyme cut-off	Pattern restriction

The problems to be resolved with regard to color filters include the uniformity of spectral characteristics and pixel forms as well as the high cost (or low yield rate). The author thinks that the coloring method is capable of

solving such problems in the current situation where the alignment film of the low-temperature process type is common. The first reason for this is that the coloring method seems superior to the pigment dispersion

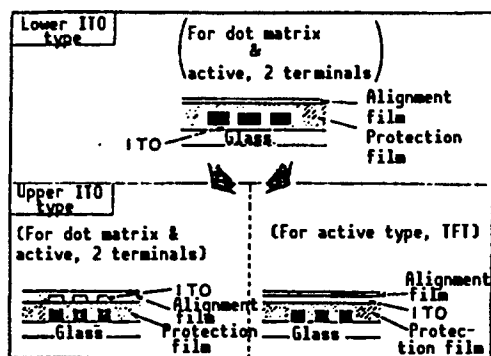


Figure 15. Structure of Color Filter

method in its uniformity of spectral characteristics and pixel forms. The second reason is that, from the standpoint of waste disposal, the coloring method is appropriate since its fully automatic process is easier to design. However, colors must be developed that will be superior in light stability and coloring effects, as well as in the photosensitive coloring resist suitable for a fully automated process.

7.5 Protective Film⁸

To improve the display quality of the color LCD, a color filter in which transparent electrodes are placed on pixels is necessary (Figure 15). Therefore, a transparent protective film that does not damage colored pixels during the transparent electrode formation process is required. Japan Synthetic Rubber, Ltd., has marketed "Optmer SS" (trademark), a transparent, heat-resistant protective film of the heat curing type. Due to its structure, the surface of the color filter is not flat. The demand for protective film with high flattening capabilities will increase in the future.

7.6 Sealant⁴

Sealant is used to seal the liquid crystal into the cell created by [two sheets of] electrode substrates with spacers in between. The sealant is constantly in contact with the liquid crystal and, therefore, requires high purity so that impurities do not contaminate the liquid crystal. It also must cut off the water and oxygen in the air. The conventional sealant is epoxy and epoxy denaturants (epoxy-acrylic and epoxy-silicon rubber), and its curing temperature is around 180°C. Problems to be resolved include attaining higher purity and lower curing temperatures.

7.7 Spacers⁴

Spacers are used to control the space between two sheets of electrode substrates and to maintain the proper thickness of the liquid crystal layer. The role of the spacer is important since, among other LCD characteristics, it has a close relationship with the response speed, contrast and visual angle of the liquid crystal layer.

Short glass fiber was used at an earlier stage, but spherical polymers with a high elastic modulus are currently in use. Bridged polystyrene and benzoguanamine have been commercialized as polymer spacers. The particle diameter of the spacers is between 2 and 8 μm , with many of them being around 5 μm . The ideal shape of the particle already manufactured is a right sphere and bridged polystyrene, as shown in Photo 1 [not reproduced].

Although one particle on the pixel cannot be seen, several particles agglomerated into particles with an average diameter of 10 μm or more become visible as a smut. Therefore, the agglomeration of particles can represent a problem in dispersing spacers. In the projection-type LCD, one spacer projects its scattered light on an enlarged display, which is viewed as defective. In order to minimize the light scattering effect, blue or black spacers are expected to be developed.

7.8 Resist

The AM LCD drive element production method, as that of semiconductors, involves the repeated forming of thin metal film and photolithography. The resist, therefore, plays an important role in controlling the drive element yield. In order for the TFT LCD to achieve a larger screen, higher definition and greater profitability, a more sensitive resist with better application and contact performance must be produced.

8. Polymers in Drive Circuit

The main organic materials used in the drive circuit are indicated in Table 6. The most important items currently seem to be the carrier film for tape automated bonding (TAB) and connectors. The importance of the print circuit substrate will increase in the future.

8.1 Print Circuit Substrate

Print circuit substrates are mainly made of glass epoxy and, corresponding to the higher definition of image quality, substrate materials suitable for finer pitch and materials with low relative permittivity of temperature reliance and with better high frequency characteristics are required.

Meeting such requirements, the substrate material of heat-cured 1- and 2-polybutadiene (JSR RB (trademark)) has been developed¹¹.

8.2 Carrier Film for TAB^{12,13}

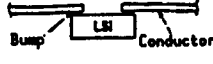
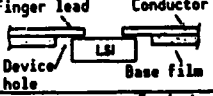

TAB is a method for mounting the drive IC on the LCD panel. Using the TAB carrier film indicated in Table 7, the drive IC is mounted according to the process illustrated in Figure 16. The carrier film is currently made of polyimide due to its heat resistance since solder is used to connect the wiring. However, polyimide is not the best material since it has problems with hygroscopicity, tear propagation strength and cost. Since the color LCD will develop toward higher definition, improvements in finer wiring and alignment precision of the electrode panel

Table 6. Main Organic Materials for Drive Circuit

Materials		Problems to be solved
1. Print circuit substrate	Substrate materials Resist, dry film	1. Solder heat-resistance, fine pitch, temperature dependency of permittivity (high density), low permittivity (high frequency)
2. TAB, carrier film		2. 3-layer TAB---Heat resistance of adhesive 2-layer TAB---Low cost Necessity of PI---Low-permittivity film
3. Connector (adhesive included)		For fine pitch Solder heat resistance 260°C Bonding heat resistance 200°C High reliability IC bonding, elimination of solder connection
4. Sealant		Stress relaxation

: Important functional materials

Table 7. Structure of Film Carrier

Type	Structure	Conductive materials	Base materials	Adhesive
Single-layered tape		Copper, aluminum 25-100 μm	—	—
Double-layered tape		Copper 18, 25, 35 μm	Polyimide 25, 50, 75 μm	—
Triple-layered tape		Copper 18, 25, 35 μm	Polyimide, polyester 50, 75, 125 μm	Epoxy 12-25 μm

and TAB pattern, as well as connection reliability, will be demanded. Therefore, reexamination and development of the carrier film, including its connection method, is necessary.

8.3 Connectors¹⁴

Connectors are used to connect the LCD panel to the drive circuit substrate. For connectors, parts are used in keeping with the method shown in Figure 17. The chip-on-glass (COG) method, which does not use the drive circuit substrate, is expected to be adopted in the future. However, since its technical problem is rather serious, the mount method employing connectors will be used for the time being.

There are two kinds of connectors—rubber connectors and heat seal connectors. Rubber connectors are subdivided into (1) the type in which rubber and conductive are layered, (2) the type in which rubber is covered with a metal and (3) the type made of rubber in which metal particles have been dispersed, causing conductive anisotropism.

Heat seal connectors consist of (1) a heat seal film in which conductive fiber is arranged and mixed to create anisotropism and (2) heat seal film into which spherical conductive material has been dispersed.

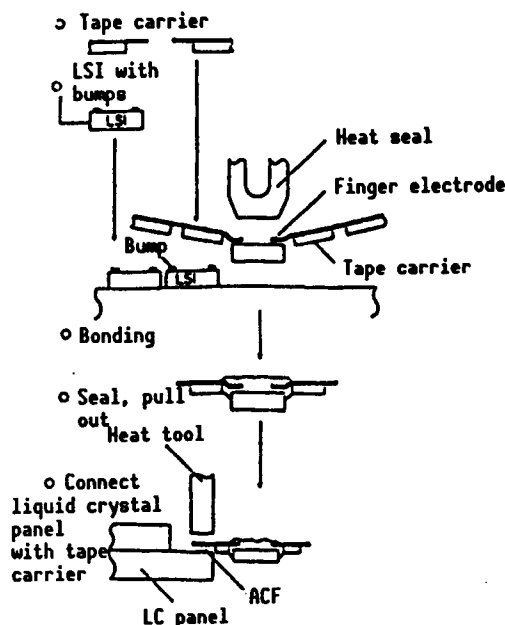


Figure 16. TAB Mounting Process

Since the reliability of the connectors controls the yield of the color LCD, connectors with high reliability, as well as improvements in the mount method, are required.

9. Conclusion

Although this discussion has been limited to color LCD's and polymers, to my regret the contents have remained rather general due to the large number of items to cover. The references can be consulted for details.

Recently, polymer dispersed liquid crystal (PDLC) has been attracting the attention of the LCD industry as a new polymer^{15,16} (Figure 18). The LCD utilizing PDLC can achieve a bright screen since it does not require a polarizing plate. When PDLC is developed for commercial applications, it will contribute greatly to solving the brightness of the projection-type LCD.

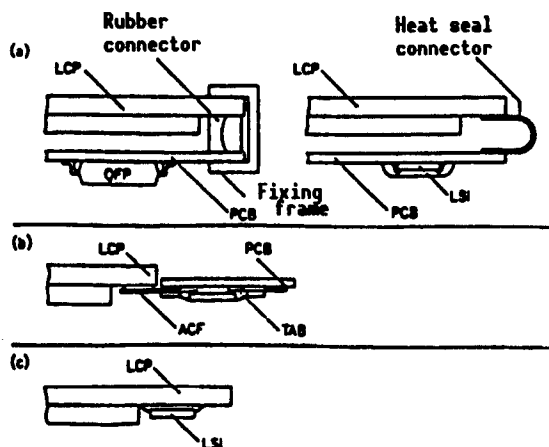


Figure 17. Drive LSI Mounting Technology for Liquid Crystal Panel

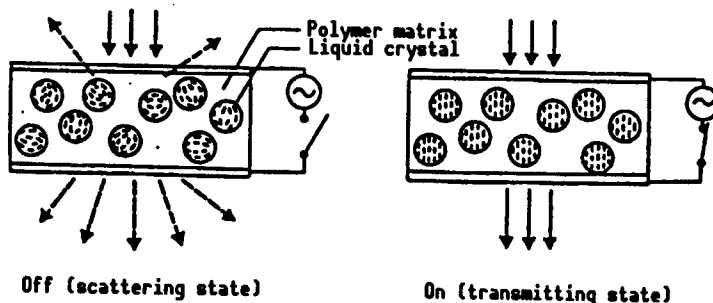


Figure 18. Principles of PDLC LCD Operation

The rear-projection-type LCD using PDLC is expected to be used domestically as a high-definition television monitor, similar to the currently popular large-screen TV.

The color LCD depends greatly on polymer functions. Those engaged in the development of polymers must continue to seek purposeful, reliable and low-cost polymers.

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Dealing With Cross-Border Transfer of Hazardous Waste

91WN0456A Tokyo CHUO KOGAI TAISAKU
SHINGIKAI in Japanese 18 Dec 90 pp 1-12

[Text] ChuKoShin No. 283; December 18, 1990

To: Ishimatsu Kitagawa, Director-General

Environment Agency

From: Jiro Kondo, Chairman

Chuo Kogai Taisaku Shingikai (Central Council for Environmental Pollution Control)

Dealing With the Cross-Border Transfer of Hazardous Waste (A Response)

Regarding inquiry No. 103 dated October 23, 1990, addressed to the Central Council for Environmental Pollution Control entitled "Dealing With the Cross-Border Transfer of Hazardous Waste," we have come to the conclusion stated on separate pages in the response.

(Separate pages)

Dealing With Cross-Border Transfer of Hazardous Waste

I. Introduction

In recent years, there have been frequent incidents that became international issues, such as the exportation of hazardous and other wastes to Africa and South America by advanced countries in Europe and North America, which caused environmental pollution due to improper disposition and unlawful dumping, or transport vessels carrying hazardous waste, etc., wandering the open sea without destination when the country of destination refused their landing.

Consequently, it has been recognized that cross-border transfer problems of hazardous waste must be met not only by advanced nations, but on a global scale that includes developing nations. The Organization for Economic Cooperation and Development is now making various decisions and recommendations regarding the management of cross-border transfers and exportation of hazardous waste. In addition, the United Nations Environmental Program adopted in March 1989 the "Basel Convention Regarding the Management of Cross-Border Transfer and Disposition of Hazardous Waste" by consensus of the 116 nations in attendance, which is expected to take effect in the near future.

Therefore, we Japanese must also be fully aware of these circumstances and accept the international responsibilities imposed on Japan. In order to meet this objective, it is necessary not only to plan the signing of the Basel Convention at the earliest possible time, but also implement necessary measures for proper cross-border transfers of hazardous waste, etc. as soon as possible.

II. Position on Dealing with the Cross-Border Transfer of Hazardous Waste

When hazardous waste is not properly managed as it crosses national borders and is transferred to various nations in the world, there is a concern that it may cause pollution by hazardous substances on a global scale.

Furthermore, the amount of waste generated in Japan has rapidly increased in recent years, with more and more complex and diverse attributes reflecting a high-technology society. On the other hand, it has become difficult, mainly in large metropolitan areas, to find plots for intermediate treatment facilities or final disposal sites for waste. In contrast, the cost of disposal or recycling in some foreign countries, for example, in developing nations, is considerably lower than that in Japan. Consequently, it is conceivable that, in the future, various wastes may be exported to various Asian nations from Japan. In such cases, the hazardous waste exported from Japan should not cause environmental pollution in developing nations.

As stated, the issues of cross-border transfer of hazardous waste are not only environmental pollution problems of a global scale, but also have another aspect of an environmental problem in developing nations. We must, therefore, be fully aware that this problem is one of the global environmental issues and should strive to solve the problem in cooperation with other nations.

III. Establishing a Program for Coping with Cross-Border Transfer of Hazardous Waste

In order to deal with the Basel Convention in a correct and amicable manner, to assure proper implementation of cross-border transfer and disposal of hazardous waste, etc., and to strive for the protection of human health and the environment, the domestic regulatory systems of the extant "Waste Disposal and Clean Environment Law" are believed to be inadequate to fully cope with these problems.

Consequently, it is necessary to develop anew domestic laws and systems with the following features and to consolidate general and comprehensive systems for the coherent management of cross-border transfer and disposal of hazardous waste.

1. Definition of hazardous waste

(1) In Japan, the scope of waste is independently regulated by the "Waste Disposal and Clean Environment Law" based on various domestic circumstances.

However, to manage globally the cross-border transfers of hazardous waste properly, it is necessary to enforce regulations based on a common concept of waste with an international consensus.

Because of these viewpoints, the Basel Convention designated 45 types of hazardous waste and two types of household waste as targets for regulation. We, in Japan,

also need new definitions of waste as regulatory targets for cross-border transfers which are in line with the Basel Convention definitions.

In this case, if waste or earth and sand, which are the sources for the so-called recycling such as reuse or recovery and use, have hazardous properties and are handled improperly, it would cause environmental pollution. Therefore, it is also necessary to manage them properly as hazardous wastes.

Furthermore, one must keep in mind that the term "hazardous waste" used here has a broad meaning, including hazardous characteristics such as explosiveness, flammability, and corrosiveness, unlike the so-called hazardous waste used to designate waste containing hazardous substances.

(2) Those types of waste that are subject to management in cross-border transfers (called "hazardous waste" hereafter) will be designated according to their hazardous characteristics, along with hazardous substances contained and the routes generated for the waste. However, to determine whether or not the waste is a "hazardous waste," technical considerations are necessary, including the establishment of protocols to determine harmfulness, the reference point and methods to analyze hazardous substances.

[Passage not received.]

5. Regulations related to reimportation

(1) In view of the fact that waste should be properly disposed of, primarily under the waste producers' liabilities, when the transfers of hazardous waste are not carried out as planned, it is necessary that the exporter, as the liable party, take measures either to use other proper disposal means or reimport the hazardous waste. In addition, when hazardous waste is unlawfully exported, i.e., without carrying out designated procedures, it is necessary that [the exporter] take proper measures to reimport the hazardous waste.

(2) It is necessary to consider measures to guarantee the financial resources of the exporters, including insurance subscriptions so that the reimportation is implemented without failure by the exporter as the liable party.

6. Penalties, etc.

In order to prevent the unlawful exportation of hazardous waste, i.e., without notification, without approvals, or false entries in transfer documents, etc., it is necessary to establish requisite penalties.

7. Others

(1) Coordination with related laws and systems

In planning the proper management of cross-border transfers of hazardous waste, it is necessary to strive for effective operations with the objective of a healthy development of both foreign trade and the national

economy, and to cooperate with various systems based on all related laws and ordinances such as the Foreign Exchange and Foreign Trade Control Laws that restrict and control imports and exports at the waterfront and the Ship's Safety Law to assure the safety of transportation by ships.

In particular, although some of the hazardous waste imported into Japan will be disposed of based on the stipulations of the "Waste Disposal and Clean Environment Law," measures to be taken against the importation of hazardous waste must be considered within the new systemic framework concerning the cross-border transfer policy in coordination with the "Waste Disposal and Clean Environment Law."

In addition, regarding the hazardous waste whose proper disposition is difficult to enforce in Japan due to environmental protection, it is necessary to take measures to ban their importation.

(2) Measures to be taken for the smooth implementation of new systems

Exporters of hazardous waste need to identify hazardous waste in applying for an export license and must also determine whether or not the means of disposition conforms to the views on environmental protection. However, conducting such clerical work requires expert technologies and knowledge.

Therefore, for the proper and smooth processing of applications, it is necessary to consider the establishment of an organization to assist in such clerical work.

IV. Preparation for disposal standards related to the "Waste Disposal and Clean Environment Law"

Compared to the hazardous wastes identified as the regulation targets by the Basel Convention, the hazardous waste designated by the extant "Waste Disposal and Clean Environment Law" has fewer kinds of targeted hazardous substances, and their forms are also limited.

[Passage not received.]

However, when a waste with the same characteristics is exported, it is handled as a hazardous waste, whereas in domestically disposing of one generated in Japan or imported, no special regulations apply. We believe this lacks regulatory balance. Consequently, in order to properly manage hazardous wastes in Japan, it is necessary to provide appropriate disposal standards in the future in order to prevent environmental pollution.

V. Promotion of Research and Development

In order to promote the proper disposal of hazardous waste and properly manage cross-border transfers as well, it is necessary to promote research and development in related technical fields such as described below while cooperating with related agencies.

(1) Volume reduction technology for hazardous waste

A very effective and effectual means for preventing environmental pollution is to reduce the volume of hazardous waste produced.

Consequently, it is necessary to promote technological development in order to limit the volume of waste discharge and to effect volume reduction as much as possible during various manufacturing and waste disposal processes.

(2) Pollution recovery measures

When hazardous waste is improperly disposed of and environmental pollution occurs, the pollutant must be swiftly removed and the previous condition must be restored. Therefore, it is necessary to determine efficient and effective measures to recover from pollution.

(3) Other investigative studies

In order to implement the management of hazardous waste more efficiently and properly in the future, it is necessary to vigorously promote investigative studies involving hazardous waste disposal standards, effective and efficient management and disposal technologies, and methodologies for understanding and evaluating the results of managing hazardous waste.

VI. International Cooperation

In order to contribute to proper hazardous waste management with respect to environmental protection, it is necessary to actively cooperate with international efforts regarding the following items with involved nations and international organizations as well as cooperate with related agencies.

(1) Information gathering and supplying

In order to properly manage hazardous waste, we must plan to be equipped with statistical values for the volume of hazardous waste generated, exported, and imported, gather technical information for dissemination and new information such as scientific findings related to hazardous characteristics, and publicize them to permit effective utilization of the information in the countries involved and by international organizations.

(2) Multinational cooperation

In the future, we must actively cooperate in technical research and development related to ways to limit hazardous waste discharge and its management as well as the formulation of manuals and guidelines which will be implemented by the nations concerned.

(3) Bilateral cooperation

In order to protect the environment in developing nations, etc., we must actively transfer hazardous waste

disposal and management techniques and provide assistance by supplying various kinds of facilities and equipment including disposal facilities, environmental protection facilities, environmental monitoring equipment, etc., and at the same time, actively cooperate by sending experts such as technicians from Japan and training local talent as well.

In addition, in implementing the development projects in which Japan cooperates, it is necessary to give full consideration to proper waste disposal as waste is generated during development. In the case of the exportation of plants, etc., it is also necessary to strive to supply pollution preventive technologies including proper waste disposal.

VII. Conclusion

As described above, the proper management of cross-border transfer of hazardous waste is an international summons to which a swift response, which includes research and development as well as international cooperation, is necessary. In particular, regarding the domestic laws and systems for managing cross-border transfers, it is appropriate to enact new laws in order to effectively and accurately enforce coherent policies against cross-border transfers in coordination with related laws and systems.

Concurrently, regarding the domestic waste policies in Japan, it is important to promote waste volume reduction by means expanding waste recycling and limiting discharge volume and to implement requisite policies so that proper waste disposal is effected through efforts to improve necessary facilities for waste disposal in parallel with the establishment of laws and systems for the management of cross-border transfers.

For Japan, who aims to be an international contributor to alleviate global scale environmental problems, it is her international duty to deal actively with global environmental issues associated with the cross-border transfer and disposal of hazardous waste. From this standpoint, it is strongly urged that she sign the Basel Convention at the earliest possible time and begin its enforcement. (Reference)

Dealing With Cross-Border Transfer of Hazardous Waste (An inquiry)

Inquiry No. 103

KanSuiKi No. 251; October 23, 1990

To: Mr. Jiro Kondo, Chairman

Central Council for Environmental Pollution Control

From: Ishimatsu Kitagawa, Director-General

Environment Agency

Re: Dealing with Cross-Border Transfer of Hazardous Waste (An inquiry)

According to the stipulation in the Basic Law for Environmental Pollution Control, Article No. 27, Paragraph 2, No. 2, we inquire as follows:

“Regarding how to deal with the cross-border transfer of hazardous waste, we seek the opinion of the Council.”
(Rationale for the inquiry)

In recent years, there have been frequent incidents that became international issues, such as shipments of large quantities of hazardous waste, unlawful dumping, or improper disposition made to various countries in Central and South America as well as West Africa by advanced nations in Europe and North America, which caused environmental pollution in the surrounding area and affected human health.

Consequently, countermeasures to the cross-border transfer problems of hazardous waste have been studied at the Organization for Economic Cooperation and

Development and the United Nations Environmental Program. As a result, the “Basel Convention Regarding the Management of Cross-Border Transfer and Disposition of Hazardous Waste” was adopted in March 1989.

Subsequently, various nations worldwide are working toward its ratification based on the chief imports of the Convention and are beginning to actively tackle the cross-border transfer problems of hazardous waste, etc.

Under such global circumstances, there arose the necessity for us Japanese to understand these problems as global environmental issues and actively work toward their solutions. In order to expeditiously ratify the Basel Convention and plan proper cross-border transfers of hazardous waste, we must plan a comprehensive undertaking which includes provisions for necessary laws and systems, related technical research and development, and promotion of international cooperation, etc.

Based on these viewpoints, this inquiry seeks opinions regarding how to deal with a cross-border transfer policy for hazardous waste, etc.

**Australia, Japan to Jointly Establish
Supercomputer Computing Center in Sydney**

91P60210A Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 23,
12 Jun 91 p 27

[Unattributed article: "Australian-Japanese Joint Venture Supercomputer Computing Station to be Set Up in Sydney"]

[Summary] After a six-month-long postponement, the Australian government has finally approved the joint Australian-Japanese establishment of a supercomputer computing center, a decision symbolizing the formation of a new technological bridge between the two nations. This new supercomputer center, located in Sydney and scheduled to begin operations in August this year, is the product of a joint venture between the Australian Nuclear Science & Technology Commission (ANSTO) and the Fujitsu, Australia Co. The new joint venture, called "Australia Ultra-High-Speed Computing Technology," will employ one US\$3.08 million VP2200 model 10 supercomputer, complete with a vector and scalar unit, a 128MB main memory, and a 25GB disk memory;

this supercomputer is scheduled to arrive in Sydney in July this year, and is the first such supercomputer to be seen in Australia.

ANSTO's portion of the joint-venture investment is 60 percent. Overall capital for the 5-year joint venture is US\$13.8 million, including an R&D budget of US\$3.8 million, of which Fujitsu has guaranteed to put up US\$1.5 million.

Fujitsu and Australian company officials have indicated that Fujitsu will transplant ANSTO's UNIX software technology into the VP2200's supercomputer applications programs, and will market the technology internationally. The new facility is mainly oriented toward institute and university users, but the official in charge of the computing center considers the instruction of [representatives from] Australian commercial firms in operation of supercomputer applications programs to be a matter of primary importance.

David Cook, Executive Director of ANSTO, commented on exaggerated reports that have been spreading about the new center. He said that talk of "Australia already having surplus supercomputer computing ability" are a complete fabrication, since all the computers in the nation are now being fully used, and the new center will fill the void in ultra-high-speed computing equipment.

MITI's Long-Range Nuclear Power Program Outlined

91FE0173A Tokyo TSUSANSHO KOHO in Japanese
6 Nov 90 pp 17-20

[Abstract] MITI's Advisory Committee for Energy has compiled a report regarding Japan's long range plan to meet increasing energy needs amidst global concern for environmental protection and resource depletion. The primary objective of the plan is to establish a supply of energy that is reliable and safe and which does not contribute to global warming or other environmental problems. Increased use of nuclear power generating facilities has been proposed as a means to meet the demand, because of its lower dependence on natural resources and the abundant supply of uranium in advanced countries.

Assuming that the economy remains stable and that restrictions are not placed on energy consumption, electrical power will account for 16.7 percent of all primary energy resources in 2010 in Japan. This means that 40 more nuclear power generating plants of the 1,000,000

kW class will have to be built in order to increase capacity from the current 31,480,000 kW to 72,500,000 kW.

With regard to nuclear power operations, the report calls for (1) the implementation of increased safety measures, (2) development of advanced technologies to ensure safety, (3) increased availability of public information regarding the safety of nuclear power operations, and (4) increased participation in international efforts to develop these technologies.

The report also indicates a need to establish a comprehensive and methodic system for re-processing and disposing of radioactive materials, and calls for the Japan Development Bank to provide low interest funding to cover the cost of recycling facilities. Since it is essential to gain the cooperation of the public in order to promote further development of nuclear power, a network is scheduled to be implemented which will provide various channels to disseminate nuclear power related information to the public and to answer questions.

Latest Developments of Optical Amplifiers

Er³⁺-Doped Fiber Amplifiers

916C0013A Tokyo OPTRONICS in Japanese
Nov 90 pp 47-53

[Article by Yasuo Kimura and Masataka Nakazawa,
NTT Transmission Systems Laboratories]

[Text]

1. Introduction

The speed of the recent development in research on optical amplifiers that use rare-earth element-doped optical fibers has been amazing, but, contrary to one's presumptions, its history does not go back very far. Research on light amplification by employing optical fibers was achieved in 1964 by Snitzer, et al., by forming fibers from neodymium (Nd)-containing crown glass¹, while the continuous oscillation of a quartz fiber laser by means of GaAs semiconductor laser pumping was reported by Stone, et al., in 1974². Since then, following the development of 1.5 μ m-band semiconductor lasers and low loss optical fibers, optical amplification by means of nonlinear effects in optical fibers, such as semiconductor laser amplification and induced Raman scattering, has become the mainstream of the research³. In the beginning of the 1980's, fault localization technology for optical fibers longer than 100 km was required, and when an erbium (Er) glass laser was developed, a broken point at 130 km was detected⁴. Light amplification by rare-earth element optical fibers began to draw renewed attention as a result of the reports on laser oscillation using fibers doped with Nd by Payne, et al., of Southampton University in 1985⁵ and on the amplification of the 1.5 μ m band Er fibers in 1987⁶. However, these required large-scale devices, such as the Ar or dye laser, as pumping sources.

Under these circumstances, in January 1989 we reported a 12.5 dB gain achieved by the Er optical fiber amplifier employing 1.48 nm band semiconductor lasers⁷. During the less than 2 year period that has followed, optical fiber amplifiers excited by semiconductor lasers have been put to practical use. The confirmation that semiconductor lasers can be used as the pumping source represents an epoch-making event in fiber amplification and, by using them, small-sized and easy-to-handle optical amplifiers with high gain, wide bandwidth, polarization-independent gain characteristic, high saturation output, low noise and low coupling loss, that are the characteristics of Er optical fibers, have been realized for the first time. The appearance of this fiber amplifier has made possible light soliton communications, which is said to represent the next-generation optical communications and, therefore, optical communications technology is

now entering the era of second generation optical communications based on fiber amplifiers^{8,9}. In this paper, the current status of Er fiber amplifiers will be reported based on the understanding of these circumstances.

2. Er-Doped Optical Fibers

2.1 Manufacture of Er-Doped Optical Fibers

An Er-doped optical fiber, as opposed to a semiconductor laser, has excellent characteristics as an amplification medium, such as the ability to obtain a high excitation density even for a small input and the ability to obtain a mutual interaction length of from several dozen centimeters to several kilometers due to its low loss, etc., because it enables a population inversion to be formed by excitation with light. Representative manufacturing methods include the vapor phase axial deposition (VAD) method and modified chemical vapor deposition (MCVD) method, and a rare-earth element is doped by a combination of one of the methods and a liquid immersion or vapor phase method^{10,11}. In Figure 1, the process of manufacturing an Er-doped fiber base material by a representative VAD method and liquid immersion method is shown. Silicon dioxide core soot is generated by the VAD method, an alcoholic solution of a rare-earth chloride is impregnated with this soot, and the product is dried in air. An Er core base material is formed by sintering the product in a chlorine atmosphere, more soot is deposited on the outside of the base material, and an Er fiber base material is obtained by sintering. A fiber is formed by drawing this base material. The features of this manufacturing method are that the VAD method makes it possible to manufacture base materials with various refractive index distributions, facilitating the production of long-length products, while with the liquid immersion method it is possible to dope Er into the core portion, enabling Al or another rare-earth element to be co-doped and the doping concentration to be controlled to within the range of 1 to 10⁴ ppm, as shown in Figure 1(b). However, as the concentration of the Er doped is increased, the Er ions are associated to form clusters, reducing the excitation efficiency. In the SiO₂-GeO₂ system, the gain begins to decrease above 100 ppm, but the Er concentration can be increased to several 100 ppm by co-doping Al¹².

2.2 Structure of Er Optical Fiber

When doping Er³⁺ ions into the core part, the pumping power becomes high at the core center and decreases as one moves toward the periphery, enabling highly efficient excitation to be obtained by doping Er³⁺ ions alone into the vicinity of the core center. This is realized by doping the Er³⁺ ions to the central part by doubling the core or the core part whose mode field diameter is 4-5 μ m and when the difference in the specific refractive index exceeds 1 percent^{8,13}.

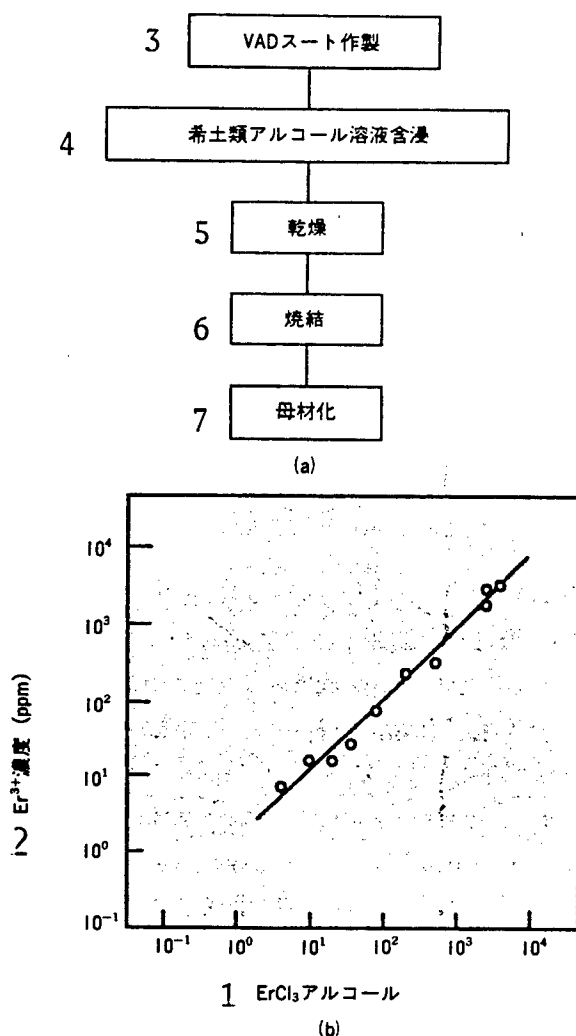


Figure 1. (a) Manufacturing of Er-Doped Based Material by VAD Method and Liquid Immersion Method, and (b) Relationship between Concentration of ErCl_3 Alcoholic Solution and Er Dosage

Key:—1. Concentration of ErCl_3 alcoholic solution—2. Concentration of Er^{3+} (ppm)—3. Manufacture of VAD soot—4. Impregnation of rare-earth element alcoholic solution—5. Drying—6. Sintering—7. Formation of base material

3. Various Characteristics of Er-Doped Optical Amplifiers

3.1 Principle of Operation of Er Fiber Amplifiers

In Figure 2, energy levels of the Er^{3+} ions doped into the fiber are shown. For amplification of the 1.5 μm band, use is made of the absorption region extending over the wavelength region of from 0.5 to 1.48 μm , forming an inverted distribution between the $^4I_{13/2}$ and the ground state $^4I_{15/2}$, so that when a signal light with energy equal

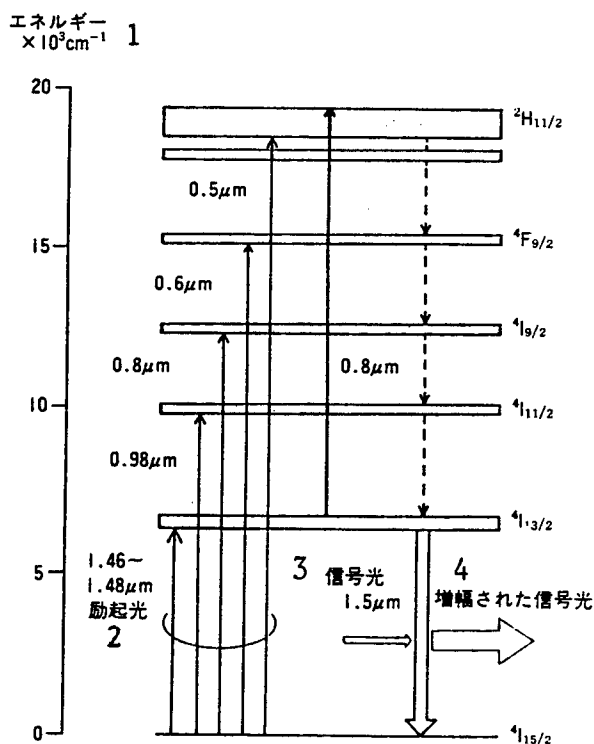


Figure 2. Energy Levels of Er^{3+} Ion

Key:—1. Energy—2. Excitation light—3. Signal light—4. Amplified signal light

to the energy between these levels is incident, the signal light is amplified by induced emission. One characteristic of the Er fiber amplification is that it forms a three-level system, as is clear from the energy levels shown in Figure 2. When the system is not excited, an absorption is present from the ground state to higher levels, so that a pumping power exceeding that of a four-level system is required in order to form population inversion. However, in a three-level system the saturation intensity of the gain becomes large with the increase in pumping power, making it suitable for power amplification, as opposed to a four-level system which is determined uniquely according to the material used.

3.2 Construction of Er Fiber Amplifiers

The structure of the basic fiber amplifier is shown in Figure 3. The optical amplifier consists of an excitation semiconductor laser, a fiber coupler, a polarization independent optical isolator, an Er-doped fiber, and an optical band pass filter. As the pumping sources, InGaAsP is used for the 1.48 μm wavelength, strained superlattice InGaAs for 0.98 μm , and the GaAlAs semiconductor laser for 0.8 μm . An optical fiber coupler or dielectric multilayered film mirror is used for the coupling of the signal light and the excitation light. An optical fiber type isolator is connected to both ends of the Er optical fiber to suppress laser oscillation by the

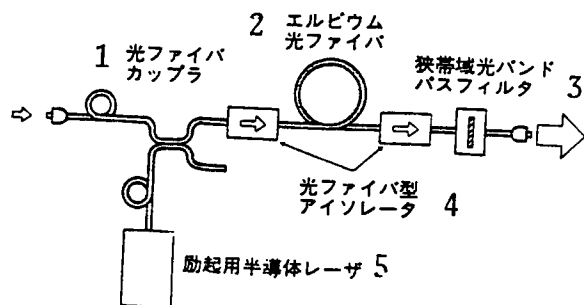


Figure 3. Example of Structure of Er-Doped Fiber Amplifier

Key:—1. Optical fiber coupler—2. Erbium optical fiber—3. Band pass filter for narrow band light—4. Optical fiber type isolator—5. Semiconductor laser for excitation

returning light. In order to take advantage of the characteristic that the gain of the Er fiber is independent of the polarization plane, the optical fiber type isolator used is non-polarized. Since the output light of the Er fiber contains amplified signal light, amplified spontaneous emission (ASE) and nonabsorbed excitation light, it is usually necessary to remove noise by using a narrow band filter of 1-3 nm.

3.3 Characteristics of Optical Amplification

3.3.1 Excitation of 0.8 μm Band

Since electrons excited to the $^4I_{13/2}$ state create excited-state absorption (ESA), in which they are further excited to the higher level of $^2H_{11/2}$, the 0.8 μm band has not been considered appropriate for excitation by Er fibers. However, it has become clear that high gain can be obtained by shifting the center of the excitation light to 820 nm. In Figure 4, the results of 0.8 μm semiconductor laser excitation are shown. The signal light input is -40 dBm (0.1 μW) and the excitation light is made to be incident from both ends of the fiber. An amplification degree of 21.6 dB is obtained for an excitation input of 53 mW, while one of 29.4 dB is obtained when the excitation input is increased to 83 mW. The gain coefficient at this time is 0.43 dB/mW. It has recently become possible to obtain a gain coefficient 0.9 dB/mW. One characteristic of this wavelength band is that it is possible to use a GaAs semiconductor laser with excellent reliability and profitability.

3.3.2 Excitation of 0.98 μm Band

Since the excitation of the 0.98 μm band has a large absorption coefficient and no ESA occurs, highly efficient excitation can be realized. In Figure 5, the dependence of the amplification degree on the excitation input is shown. A fiber with a high specific refractive index difference of 1.67 percent and a mode diameter of 4.8 μm is used. Although it has been reported that a gain efficiency of 10.2 dB/mW was obtained for a fiber length

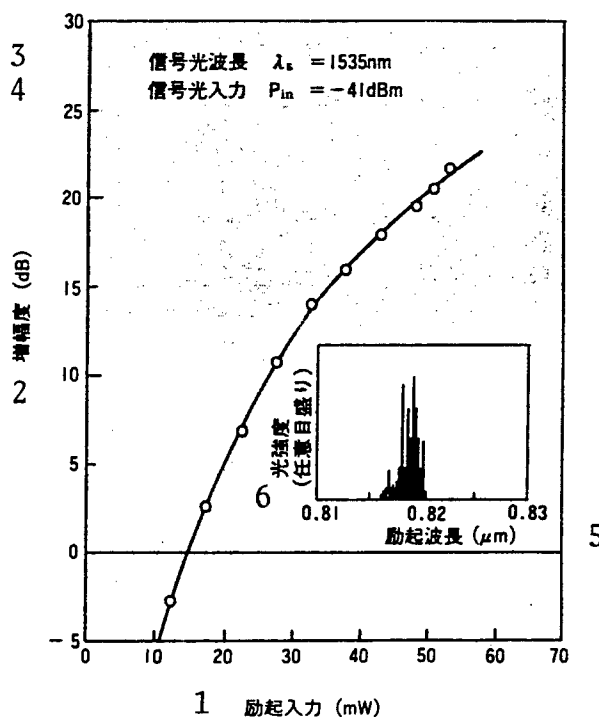


Figure 4. Amplification Characteristics of 0.8 μm Band
Key:—1. Excitation input—2. Amplification degree (dB)—3. Signal light wavelength—4. Signal light input—5. Excitation wavelength (μm)—6. Light intensity (arbitrary scale)

of 10-23 meters, the highest amplification degree (39 dB) has been obtained for a fiber length of 30 meters and an excitation input of 9 mW. The effective excitation wavelength of the 0.98 μm band is approximately 10 nm, centered around 980 nm.

3.3.3 Excitation of 1.48 μm Band

Excitation of the 1.48 μm band exhibits high efficiency because no ESA occurs, but its main characteristic is that the excitational absorption and the induced emission use the same $^4I_{13/2}$ and $^4I_{15/2}$ level interval. In Figure 6, the dependence of the amplification degree on the excitation input is shown. The pumping source is a 1.48 μm band semiconductor laser, while the fiber is the same high efficiency fiber used in Figure 5. An amplification degree of 33 dB and a gain coefficient of 5.1 dB/mW are obtained for a fiber length of 90 meters and an excitation input of 9 mW. It becomes necessary to have a longer fiber than that used for the 0.98 μm band because of the lower absorption coefficient. In the 1.48 μm band excitation, a high gain can be realized over the wide range of from 1.450 to 1.485 μm , centered around 1.475 μm . Therefore, the InGaAsP semiconductor laser, which oscillated in a longitudinal multimode, can be used as a highly efficient pumping source, and the degree of freedom for the selection of semiconductor lasers for

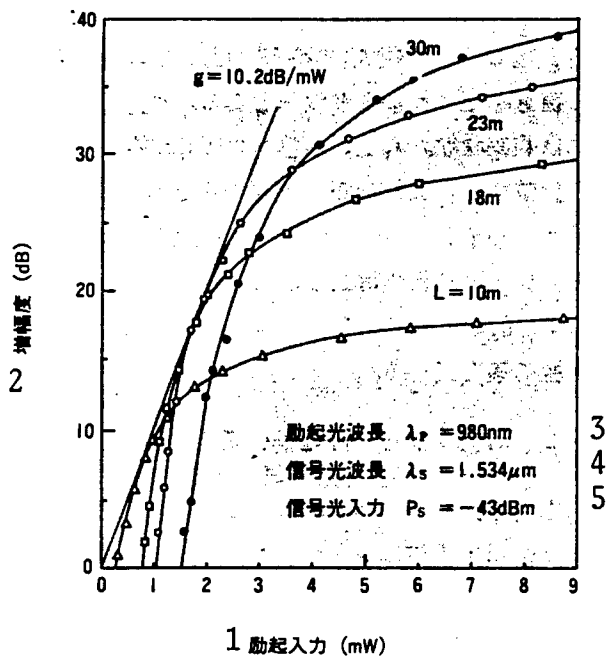


Figure 5. Amplification Characteristics of 0.98 μm Band
Key:—1. Excitation input—2. Amplification degree—3. Excitation light wavelength—4. Signal light wavelength—5. Signal light input

excitation is increased for the excitation of the 1.48 μm band in comparison with that for the 0.98 μm band.

3.4 Light Output Characteristic

Since the excitation efficiency is low for the 0.8 μm band, the light output obtained is 1 mW for an excitation input of 83 mW, and the conversion efficiency of the signal light output to the excitation light is 1.2 percent. Recently, however, an efficiency of 12 percent has been obtained by using a fiber with a high specific refractive index difference. During 0.98 μm band excitation, an amplified light of 140 mW has been obtained for an excitation input of 180 mW, with a conversion efficiency of 81 percent. It can be said that the excitation wavelength of the 1.48 μm band is appropriate when optical fiber amplifiers are used as the optical power amplifiers.

3.5 Noise Characteristic

The Er fiber amplifier output consists of an amplified signal light and an ASE with a wide spectral width. The noise generated during light detection consists of (1) the shot noise of the amplified signal light, (2) the shot noise due to ASE, (3) the signal-spontaneous beat noise generated by light mixing of the ASE spectral component and the amplified signal light, and (4) spontaneous-spontaneous beat noise between the ASE spectral components. Light amplification with low noise can be realized by reducing the noise in (3) by using a low signal light input and by reducing the noise in (4) through the

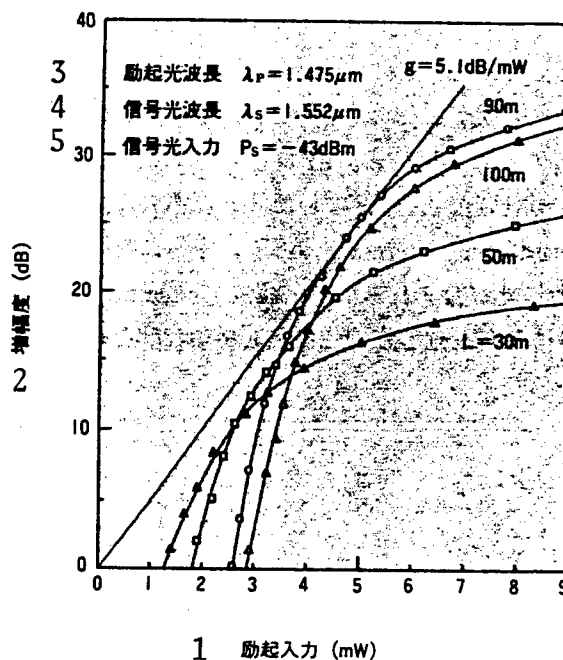


Figure 6. Amplification Characteristics of 1.48 μm Band
Key:—1. Excitation input—2. Amplification degree—3. Excitation light wavelength—4. Signal light wavelength—5. Signal light input

insertion of a narrow band filter. In Figure 7, the input signal light dependence of the noise is shown. The principal noise component is the spontaneous-spontaneous beat noise for input signal light below -50 dB and the signal-spontaneous beat noise of (3) for input signal light above -40 dB. The noise factor (NF) for the optical amplifier is 3.2 dB for the 0.98 μm band and 4.1 dB for the 1.48 μm band. These values are lower than the 5.2 dB noise figure obtained for the semiconductor laser amplifier, indicating that the Er fiber amplifiers are optical amplifiers with low noise.

3.6 Optical Pulse Amplification Characteristic

The response to the population inversion of Er optical fiber amplifiers is slow, so for pico (10^{-12})-second optical pulses it has the characteristic that the amplification degree is determined by the average incident power. In Figure 8, the amplification characteristic of optical soliton pulses with a pulse width of 98 picoseconds and peak power of 63 mW, 126 mW and 189 mW, obtained by an Er-doped optical fiber amplifier excited with a 1.48 μm semiconductor laser, is shown. It is possible to amplify optical solitons with peak power of from 50 to 100 mW to over 10 dB by using the small excitation light input of 50 mW. Figure 9 shows the optical amplification characteristic of an optical soliton with a pulse width of 0.7 picoseconds and peak power of 43 W, as well as those of optical solitons with pulse widths of 0.9 picoseconds and peak powers of 12 W and 40 W.

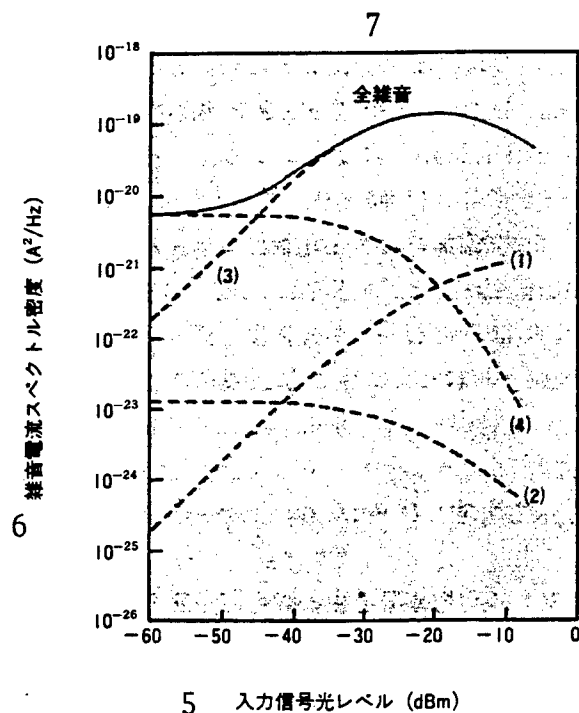


図7 雑音電流スペクトル密度の信号光入力依存性

- (1)信号光ショット雑音
- (2)ASEショット雑音
- (3)信号光-ASEビート雑音
- (4)ASE-ASEビート雑音

Figure 7. Dependence of Noise Current Spectral Density on Signal Light Input

Key:—(1) Signal light shot noise—(2) ASE shot noise—(3) Signal light-ASE beat noise—(4) ASE-ASE beat noise—5. Input signal light level—6. Noise current spectral density—7. Total noise

Amplification degrees of 2.8, 5.5 and 3.8 dB are obtained for optical pulses of 43, 12 and 40 W, respectively, for an excitation light input of 90 mW. Since an Er optical fiber amplifier can amplify, without distortion, optical pulses with peak values of several dozen watts with a relatively low excitation input, it can be used for optical soliton communications. We were able to observe optical solitons with no pulse width spread, even for a propagation distance of 400 km, and have realized optical soliton communications with an error rate of less than 1×10^{-9} . By utilizing the entire 30-40 nm band of the Er-doped fiber, it is possible to amplify an optical pulse of 100 fs (10^{-15} seconds) with an Er optical amplifier excited by a 1.48 μ m semiconductor laser. In Figure 10, the excitation input dependence of the output pulse width of femtosecond solitons is shown. The pulse width of the

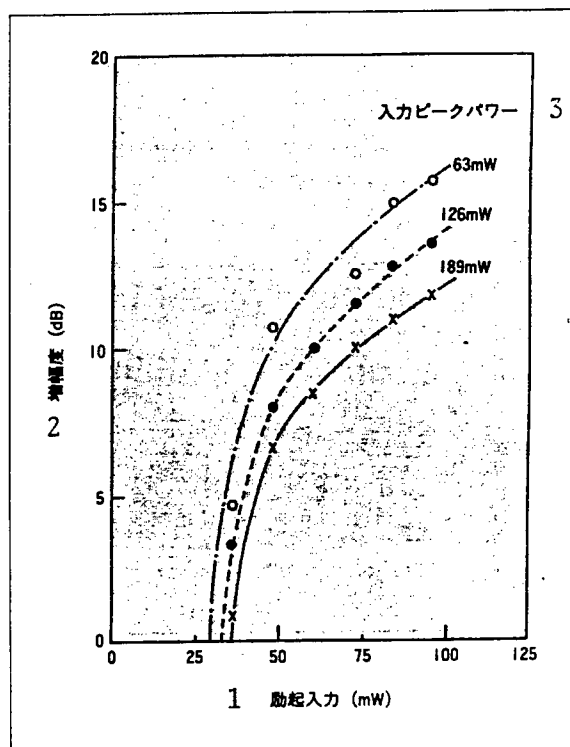


Figure 8. Amplification Characteristics of Picosecond Soliton Pulse

Key:—1. Excitation input—2. Amplification degree—3. Peak input power

output soliton decreases monotonically with the increase of the excitation input, and an input pulse of 240 fs is converted to 60-80 fs. This is caused by the narrowing of the pulse width corresponding to the amount of the peak value due to the adiabatic narrowing of the soliton within the gain medium and by the occurrence of a self frequency shift in the soliton. In this experiment, a gain of 9 dB is obtained for an input pulse with a width of 240 fs and a peak power of 30 W.

4. Fluoride Optical Fiber Amplifiers

For 1.3 μ m amplification it is necessary to dope with Nd, but it is not possible to obtain a gain in a quartz fiber due to the occurrence of ESA. However, by changing the glass composition to a fluoride ($\text{ZrF}_4\text{-BaF}_2\text{-LaF}_3\text{-AlF}_3\text{-NaF}$), a maximum gain of 5.5 dB is obtained for a signal input of -25 dBm at a 1.34 μ m wavelength. For a fluoride optical fiber amplifier doped with Er, an amplification degree of 20 dB is obtained for a fiber length of 50 cm. In a fluoride system it is possible to dope Er more than 10 times as much as that of a quartz system, and it has characteristics, such as the flattening of the wavelength characteristic of the gain, which cannot be found in the quartz system.

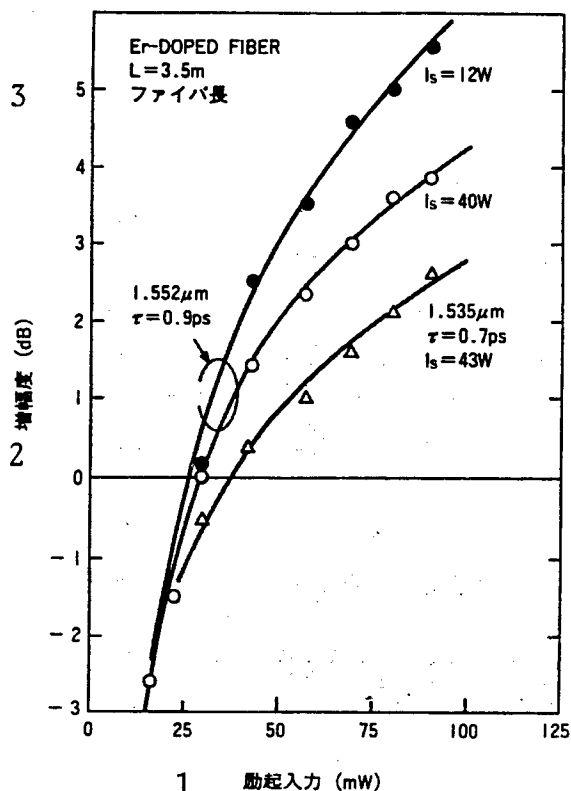


Figure 9. Amplification Characteristics of Sub-picosecond Optical Pulses

Key:—1. Excitation input—2. Amplification degree—3. Fiber length

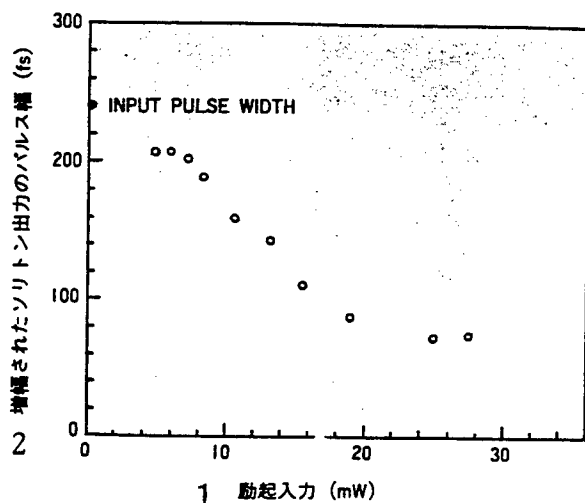


Figure 10. Excitation Input Dependence of Output Pulse Width of Femtosecond Solitons

Key:—1. Excitation input—2. Pulse width of amplified soliton output

5. Conclusion

The manufacturing, amplifier construction, amplification characteristics, output characteristics, noise characteristics and optical amplification characteristics of Er-doped optical fiber amplifiers have been described, focusing on the Er optical fiber amplifiers. In particular, the Er optical fiber amplifiers have excellent characteristics as optical amplifiers, such as enabling high gains to be obtained in the minimum loss wavelength region of optical fibers, low insertion loss for in-line type devices, low noise, etc. In addition, since it is possible to amplify femtosecond optical pulses, the possibility of their application not only to the field of optical communications, but also to the fields of laser control and optical instrumentation, as well as significant advancements in the field, are expected in the future.

Recent Progress in Semiconductor Optical Amplifiers

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pp 54-58

[Article by Shinji Tsuji, Optoelectronics Research Department, Central Research Laboratory, Hitachi, Ltd.]

[Text]

1. Introduction

An optical amplifier is a device which amplifies an optical input signal directly as light without converting it into an electrical signal. Its characteristics include (1) the response frequency band is as high as 1,000 GHz, (2) it is independent of the signal form, such as its intensity modulation, frequency modulation, etc., and its speed, (3) it is possible to batch amplify a wavelength multiplexed signal, (4) it has a simple structure, etc. Because of this, it is attracting notice for its applications to gigabit optical transmission devices, such as relay amplifiers, pre-stage amplifiers, etc., as well as for its applications to the CATV distribution system, such as in branching loss compensators, etc. These technologies will develop with the realization of the future wideband ISDN, and the role played by optical amplifiers is expected to grow, year by year, as the next century approaches. In this paper, the current status of the semiconductor optical amplifier will be described, focusing on reports from OA'90 (Topical Meetings on Optical Amplifiers and Their Applications) together with the results obtained by the author's group.

In a semiconductor optical amplifier, light amplification is executed according to the same principle (induced emission due to inter-band transitions) as in a semiconductor laser. Because of this, it has characteristics similar to those of semiconductors, such as small size, low power consumption, excitable with a current, etc. Further, the ease of integration is an advantage that cannot be overlooked.

Research on semiconductor optical amplifiers was originally advanced on the basis of the GaAlAs laser. Currently, investigations of devices that use InGaAsP material, generating a gain in the wavelengths of the 1.3 and 1.55 μm bands, are being conducted. Table 1 lists the contents of papers presented at OA'90 related to semiconductor optical amplifiers. The main topics included (1) rendering the gain independent of the polarization state of the input light, (2) increasing the saturation output, (3) high efficiency coupling to the optical fibers/forming them into modules, (4) nonlinear interaction, (5) development into optical integrated circuits, etc.

Table 1. Contents of Papers Reported at OA'90

Item Being Investigated		Paper Number
Element Structure	Reduction of Reflection from End Faces	ME2, PD5
	Rendering Polarization Independent	MC2, ME3, PD5
	Increasing Output	MC3
	Others	ME4
Module/Photocoupling		ME1, ME2
Nonlinear/Noise		TuE1, TuE2, TuE3, TuE4, TuE5
Modulation, etc.		WC2, WC3
Integration		ME5, WC1
Others	Comprehensive Report	MC1
	Element Evaluation	MC4
	Other Applications	WC4, WC5

2. Reduction of Reflectivity of Element End Faces

Since an optical amplifier element consists of a crystal of InGaAsP, etc., and has a high index of refraction of

3.2-3.5, light is reflected from the end faces of the element. Although, as a laser, a semiconductor laser utilizes this reflection during operation, the reflection is not wanted by an optical amplifier which responds solely to incident light from the outside. If a reflection occurs at an end face, it comes to have the same structure as a Fabry-Perot resonator, so that such problems arise as (1) the gain changing periodically in response to the change in the wavelength of the incident light, (2) the gain becoming saturated due to the generation of laser oscillation, along with the increase in the excitation current, etc. If the ripple (the ratio of peak to valley) of the gain is to be suppressed to below 1 dB (1.25 fold) at the 30 dB gain of the element (1,000 fold), the reflection from the end face has to be controlled to less than 0.005 percent. Because of this, in order to reduce the reflectivity, various means, such as those shown in Table 2, have been devised. Among them, the window structure (NEC: IOOC'89, 20C2-2), in which the light guide is truncated so as not to reach the end of the element, has an affinity with a polarization independent waveguide. According to a report from OA'90, a reflectivity of 0.0036 percent is obtained by combining the oblique waveguide and the window structure (Hitachi, Ltd.: PD5). In addition, there is a report that a reflectivity of 0.001 percent has been obtained by increasing the conventional angle of 7° to 10° in the oblique waveguide system (Technical University of Denmark: ME2).

3. Rendering Polarization Independent

In optical fiber communications, a single mode fiber is used for the input and output of the optical amplifier. Since the cross section of a waveguide for a semiconductor amplifier is a rectangle, there are two polarization states (TE wave and TM wave), and the gain is generally different for these two states. On the other hand, the propagation mode of an optical fiber is cylindrically

Table 2. Method for Reducing End Face Reflectivity

1 方式		2	3	4
項目		無 反 射 膜 形 成	斜 め 導 波 路	窓 構 造
5	項目			
6	構 造			
7	特 徴	○レーザ特性との対応可能 14 ●膜構造の精密制御が必要 15	○リッジ型導波路構造に有効 16 ○AR膜形成条件緩和できる 17 ●無偏波導波路では不可 18	◎無偏波導波路構造に有効 19 ○AR膜形成条件緩和できる 17
8	機 関	NTT, CNET, AT&T...	Bellcore, BTRL...	NEC, AT&T...

Key:—1. System—2. Formation of nonreflecting film—3. Oblique waveguide—4. Window structure—5. Item—6. Structure—7. Characteristics—8. Organization—9. Input—10. Waveguide—11. Low reflecting film—12. Output—13. Reflected light—14. Possible to make correspondence with laser characteristics—15. Accurate control of film structure necessary—16. Effective for ridge-type waveguide structure—17. Conditions for AR film formation can be relaxed—18. Nonpolarized waveguide is not sufficient—19. Effective for nonpolarized waveguide

symmetric, and the polarization state of the propagation mode varies with the change in the stress applied to the fiber, which depends on changes in vibration and temperature. As a result, the gain becomes unstable with time. For this reason, in systems where amplification is applied after transmission by fiber means, it becomes necessary to have a polarization-independent optical amplifier for which the gain does not depend on the polarization state of the input wave.

The cause of the polarization dependence of the gain of a semiconductor optical amplifier element is the difference in the electric field distribution of light for TE and TM waves. A proposal was made (NTT: MC2) to aim for polarization independence by relatively increasing the gain coefficient of a TM wave by the use of a multiple quantum well (MQW), in addition to aiming at it (CR-CGE: ME3; Hitachi, Ltd.: PD5) by arranging electric field distribution by controlling the waveguide form, such as increasing the thickness and decreasing the width of the active layer. In addition, the difference in the resonant frequency of the gain ripples for a TE wave and a TM wave affects the polarization dependence. In order to eliminate the polarization dependence, it is necessary to reduce the reflection from the end faces.

An example of an optical amplifier element (Hitachi, Ltd.: PD5) with extremely small polarization dependence is shown in Figure 1. Its basic structure is approximately the same as that of a semiconductor laser which has a buried stripe-shaped waveguide within an InP crystal. Light is incident on one of the end faces of the waveguide, and amplified light is output from the end face on the opposite side. The waveguide's structure is such that an InGaAsP layer is sandwiched between an InGaAsP light guide layer and an InP cladding layer. By controlling the thickness and the width of each layer of the waveguide, the polarization dependence is suppressed to approximately 0.4 dB, for a gain of 28 dB. In order to prevent the reflection, a window region (approximately 25 μm) is provided on both ends of the waveguide, the waveguide is tilted 6° with respect to the end faces of the waveguide, and a reflection-preventive film is formed on the end faces. With this configuration, it is possible to suppress the effective reflectivity of the end face to 0.0036 percent and the gain ripple to about 0.4 dB. As a result, the gain difference between the TE wave and the TM wave has almost been eliminated, as shown in Figure 2. Under a 28 dB gain of the element, the overall polarization dependence has been lowered to less than 1 dB.

4. Increasing Output of MQW Optical Amplifiers

For applications such as batch amplification and post-stage amplification of wavelength multiplexed waves, it is preferable to have amplifiers with high output. For this reason, semiconductor amplifiers with a MQW structure of the active layer are attracting attention. An optical amplifier has a constant gain when the optical output is small (unsaturated state). However, with an increase in the optical output, the injection of carriers fails to follow

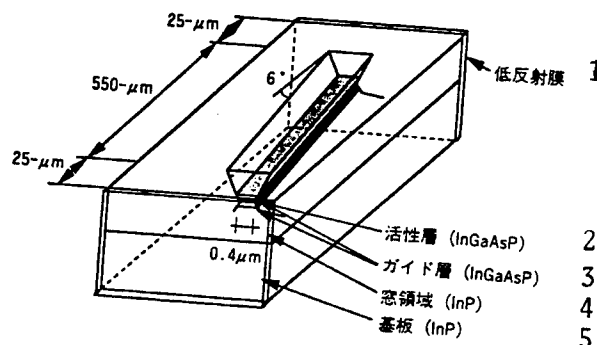


Figure 1. Structure of a Semiconductor Optical Amplifier Element with Low Polarization Dependence

Key:—1. Low reflection film—2. Active layer—3. Guide layer—4. Window region—5. Substrate

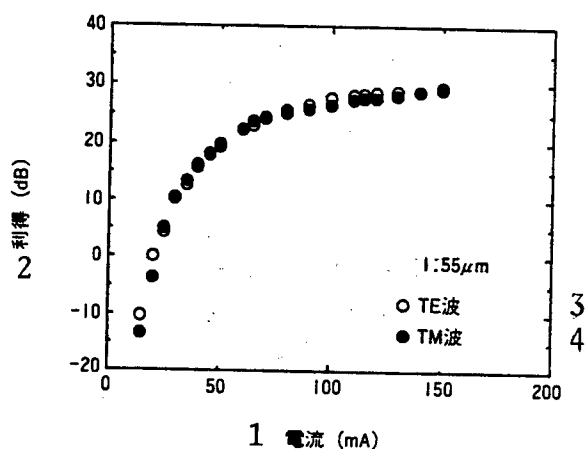


Figure 2. Amplification Characteristics of Semiconductor Optical Amplifier Element (current dependence of TE and TM wave gains)

Key:—1. Current—2. Gain—3. TE wave—4. TM wave

the consumption and the gain decreases. The output value at which the gain is one-half that of the unsaturated state is referred to as the saturated output value. The relationship between the saturated output value and the gain is shown in Figure 3. Since the saturated output value is proportional to the extent of the interaction between light and the carrier, it is inversely proportional to the confinement coefficient (the rate at which light is distributed in the active layer) of light. Since the light confinement coefficient of a MQW amplifier is smaller than that of a conventional amplifier by about one order of magnitude, the saturated output value is increased. In a conventional amplifier it is about 5-10 mW, but there are reports that it has reached 42 mW (AT&T: IOOC'89, 20PDB-13) and 115 mW (BTRL: OFC'90, PD32) for MQW amplifiers.

Another problem with the MQW amplifier is the reduction of the amplification degree accompanying the light

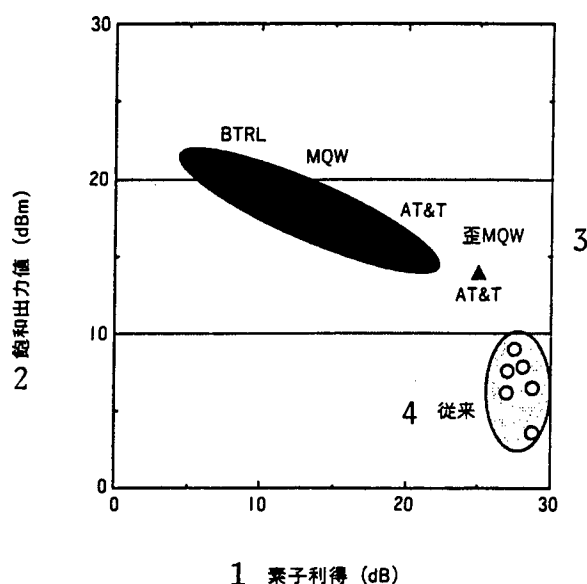


Figure 3. Relationship Between Saturated Output Value and Element Gain

Key:—1. Element gain—2. Saturated output value—3. Strained MQW—4. Conventional device

confinement coefficient. The gain of an element with a saturated output value of 42 mW is 19 dB, while it is only 8 dB for an element with a 115 mW output. Because of this, attempts have been made to improve the gain by employing a strained quantum well layer in the active layer. There has been a report that a gain of 25 dB, comparable to the conventional value, has been obtained, with a saturated output of 25 mW (AT&T: MC3). In addition, it was reported that the nonlinear interaction, such as that in four light wave mixing, in a MQW amplifier is small (AT&T: TuE5), and future investigations of these topics are expected.

5. Suppression and Active Utilization of Nonlinear Interaction

If the optical signals of two or more waves are incident on a semiconductor amplifier which is in the state of gain saturation, a mutual interference is generated among signals. This occurs as a result of sharing the gain (carrier density) among signals. Due to this effect, the number of wavelength multiplexed signals is limited. Moreover, when the frequency difference between light waves is as small as several gigahertz, carrier density pulsation is generated within the amplifier, producing crosstalk due to the mixing of four waves in quasi degeneration. This effect becomes a factor limiting the signal spacing in a frequency multiplexed coherent frequency-division-multiplexed (FDM) transmission system. In order to prevent this from happening, it is necessary to use an optical amplifier with high saturated output, as mentioned above.

There has also been a proposal to make active use of four light wave mixing as a highly efficient wavelength conversion element (HHI: OFC'89, PD13). Since the conversion in four light wave mixing is carried out while retaining the phase information, it has the advantage that it is possible to convert coherent signals.

6. Optical Amplifier Module: Photocoupling with Single Mode Fiber

For applications to optical fiber communications, optical amplifier modules which incorporate single mode fibers in the input and output parts are indispensable. In such a module, highly efficient photocoupling is required between an optical fiber and an amplifier element from the viewpoint of obtaining an effectively high gain between the fibers, preventing deterioration of the S/N (signal to noise ratio), etc. This is because the main noise accompanying the use of an optical amplifier is the beat noise produced when a spontaneously emitted light generated within the optical amplifier and a signal light enter a photodetector, while the amount of reduction in the input signal light due to the coupling loss corresponds directly to the deterioration in the noise figure, NF. It should be mentioned that NTT, BTRL, etc., have reported values in the range of from 5.2 to 6.3 dB as the measured values for the NF of the elements.

As for photocoupling systems, there is one system that uses a fiber provided with a lens action on its tips by machining, and another system that employs a confocal system lens. A coupling efficiency of approximately -3 dB for each end has been obtained. As for a module, a gain of 18 dB between fibers has also been reported (Hitachi, Ltd.: MF1; NEC: '90 Spring Meeting of Communications Society of Japan, C266). In September of this year, the author and his colleagues reported on an optical amplifier for the 1.55 μm wavelength which incorporates a low polarization dependent element (Technical Report of Communications Society of Japan, OQE90-74). Figure 4 [not reproduced] is a photograph of a module, showing its internal configuration. A selfoc lens set is used as the photocoupling system, and a coupling efficiency of -5 dB, a polarization dependence of less than 1 dB and an inter-fiber gain of 17 dB (50-fold) have been realized.

7. Others

Applications of optical amplifiers to phase modulators and optical switches can be studied. An attempt to compensate for the coupling loss and the waveguide loss by incorporating an amplifier into an optical switch has been reported (Hitachi, Ltd.: PS'90, 14D-6; BTRL: WC1). In addition, a report has been made on integrating the optical amplifier with a waveguide-type photodetector to monitor the amplification degree (AT&T: ME5). In such a system, it is necessary to search for an element structure that will facilitate integration with the waveguide.

Transmission experiments that use the semiconductor optical amplifier are being carried out by KDD, BTRL,

AT&T and other research organizations (IOOC'89, 20 PDA-9; 21B2-2). In the author's laboratory, a semiconductor amplifier is being used as a wideband pre-stage amplifier for a photodetector by paying attention to the wide bandwidth of the optical amplifier, and a 40 km transmission has been successfully generated by four wavelength multiplexing of 10 gigabit signals (ECOC'90, WeF1.1). Since semiconductor optical amplifiers have the advantage of being compact and having low power consumption, various applications of optical amplifiers in optical fiber communications are expected.

The application field for optical amplifiers is not limited to optical communications. A table-top electrooptical (EO) sampling device (Tokyo University: WC4), in which the conventional YAG laser has been replaced by a semiconductor laser, is a worthwhile example of an application of a short optical pulse amplifier.

8. Conclusion

The recent advances in semiconductor optical amplifiers may be said to be represented by their having been rendered polarization independent and by the increase in the output of the MQW elements. An element with a polarization dependence degree of less than 1 dB for an amplification degree of 28 dB has been realized. An amplifier module with an amplification degree of 17 dB that incorporates this element has been obtained, and is expected to open the way to practical applications. In addition, new applications of the MQW structure to the optical amplifier, such as rendering the optical amplifier polarization independent and increasing the output, have been introduced. The future development of the MQW structure is expected to include enhancing its functions, such as switching, modulation, etc., through optical integration.

Pumping Sources for Optical Fiber Amplifiers

916C0013C Tokyo OPTRONICS in Japanese Nov 90 pp 59-66

[Article by Toshio Nonaka, R&D Group, Oki Electric Industry Co., Ltd.]

[Text]

1. Introduction

It may be said that the appearance of the erbium-doped fiber amplifier (EDFA), made by doping an optical fiber with the ions (Er^{3+}) of the rare earth element Er, has had a strong impact on the advancement of optical communications technology, which is experiencing increasingly accelerated innovations.

The characteristics of the EDFA may be listed as follows:

- (1) It has high amplification efficiency. Through excitation with a laser diode, a gain exceeding 30 dB can be obtained.
- (2) It has low noise (noise figure (NF) < 4 dB).
- (3) The gain is not dependent on the polarization.
- (4) Its time response is fast, and it is possible to have a high speed response of less than several picoseconds.
- (5) It has a high saturated output, with a maximum of greater than 10 dB obtainable.
- (6) The life of the doped Er^{3+} is long (14 ms in comparison to 0.1 ns for a semiconductor amplifier), and no pulse pattern effect is generated during the amplification of a high speed optical pulse string.
- (7) Since the amplifier itself is made of an optical fiber material, it is essentially possible to connect it to the fiber for transmission with low loss.
- (8) The amplification band for the signal light is 1.52 to 1.56 μm , which coincides with the low loss wavelength band of the quartz fibers normally used for transmission.

The energy levels of an optical fiber doped with Er^{3+} and a conceptual diagram illustrating the principle of optical amplification are shown in Figure 1. The absorption bands of the Er^{3+} ion are found at wavelengths of 0.51, 0.66, 0.81, 0.98 and 1.48 μm , and light rays of these wavelengths act as the excitation light to excite the Er^{3+} ion to high energy levels. If a signal light (1.53-1.55 μm) is input to an Er^{3+} in an excited state, an induced emission takes place and the output of the signal light is amplified along the optical fiber. This is the principle behind the EDFA operation. Accordingly, one can say that a pumping source is one of the EDFA's indispensable devices. In Figure 2, the basic EDFA configuration is shown. An EDFA consists of a pumping source for exciting the Er^{3+} species, a fiber coupler for confining an excitation light and an input light signal (1.52-1.58 μm), an Er-doped optical fiber (EFA) which serves as an amplifying medium, an optical isolator, etc. The amplification capability of the amplifier has been enhanced as a result of research on EDF, and it has become possible to amplify outputs ranging from several watts to several hundred milliwatts produced by conventional high power Ar ion lasers or dye lasers. In other words, high power semiconductor lasers have been brought onto the scene to play their important roles. There is no doubt that by using semiconductor lasers as pumping sources, it will become possible to overcome such practical problems as making the system compact and lightweight, enhancing its reliability and reducing its cost. Therefore, in Figure 1, the excitations of the 0.81, 0.98 and 1.48 μm wavelength bands, all of which are greater than the 0.67 μm that is obtainable through the continuous oscillation of semiconductor lasers operating at room temperature, are shown. In this review, the current status of the EDFA pumping sources will be presented by paying particular attention to semiconductor lasers.

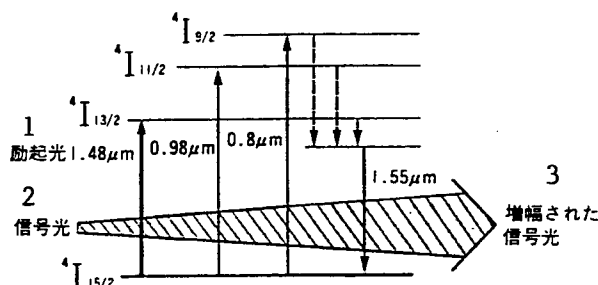


Figure 1. Energy Levels of Er^{3+} Ion and the Principle of Optical Amplification

Key:—1. Excitation light—2. Signal light—3. Amplified signal light

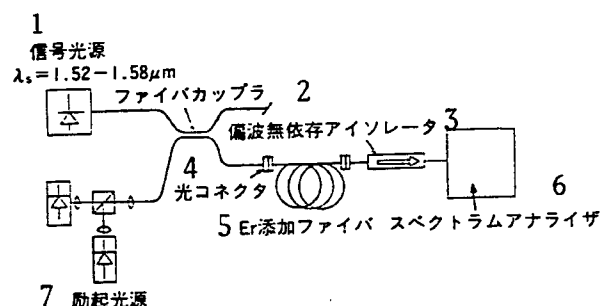


Figure 2. Basic Configuration of EDFA

Key:—1. Signal light source—2. Fiber coupler—3. Polarization independent isolator—4. Optical connector—5. Er-doped fiber—6. Spectrum analyzer—7. Pumping source

2. High Power Semiconductor Lasers as Pumping Sources for EDFA

Among the three excitation wavelength (0.81, 0.98 and 1.48 μm) bands for EDF, a high gain cannot be obtained with the excitation of the 0.81 μm wavelength band due to Er^{3+} ion absorption from a quasi stable level (excited state absorption: ESA), which is an excited state shown in Figure 1. Accordingly, semiconductor laser diodes in the 1.48 and 0.98 μm bands, for which ESA does not occur, are currently being actively developed as pumping sources for the EDFA. In the following, the development status of semiconductor laser diodes as the EDFA pumping sources will be reported by referring to the latest papers presented at technical meetings and published in journals.

2.1 1.48 μm Band Semiconductor Lasers

The semiconductor laser diodes reported so far for use in the excitation of this wavelength employ InP as the substrate, and are at the stage where reports are being published as to the means for elevating the output power and reliability during high power operation.

First, there was Oki Electric Co.'s report on the V-grooved inner stripe diode on the P-type substrate

(VIPS)-LD that utilizes the characteristics of liquid phase epitaxy (LPE). The sectional structure of the device is shown in Figure 3. Its characteristic is that it uses a P-type InP substrate, and is fabricated by a two-stage LPE process. After sequentially depositing a P-type InP buffer layer, a N-type blocking layer and a P-type blocking layer, a V groove is etched in the part intended for a laser resonator, while in a second deposition a P-type InP cladding layer, a GaInAsP active layer, a N-type InP cladding layer and, as the uppermost layer, a N^+ -type GaInAsP layer are formed. Important points for high output operation include the structure of the blocking layer and the design of the crescent-shaped active layer. Figure 4 shows the output-current (L-I) characteristics of a VIPS-LD, given a resonator length of 700 μm , a treatment for a front end face reflectivity R_f of 5 percent and a back end surface reflectivity R_b of 32 percent. A maximum output of 190 mW at 20°C and continuous oscillation, even at temperatures of as high as 110°C, are obtained. In addition, as to the reliability, an automatic power control (APC) test at the high output operation of 110 mW produced no observable deterioration after a lapse of more than 5,000 hours. Currently, the mean life of this laser diode is estimated at more than 10^5 hours.

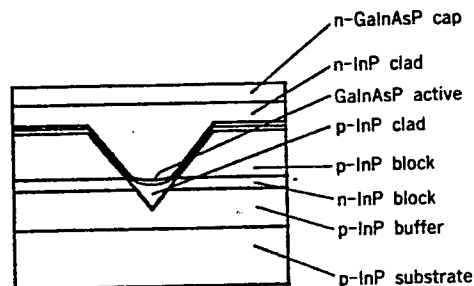


Figure 3. Sectional View of GaInAsP-VIPS LD

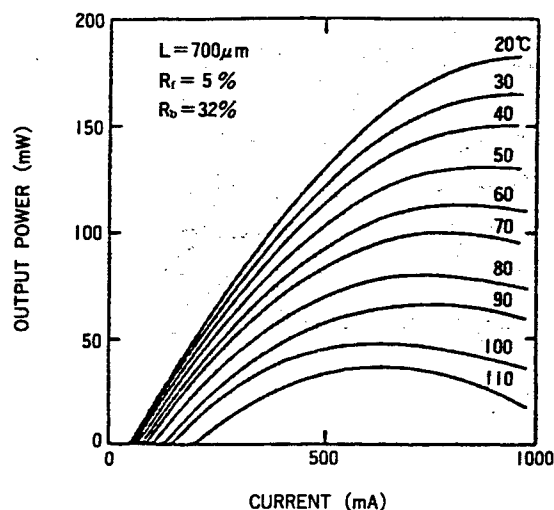


Figure 4. L-I Characteristics of VIPS-LD

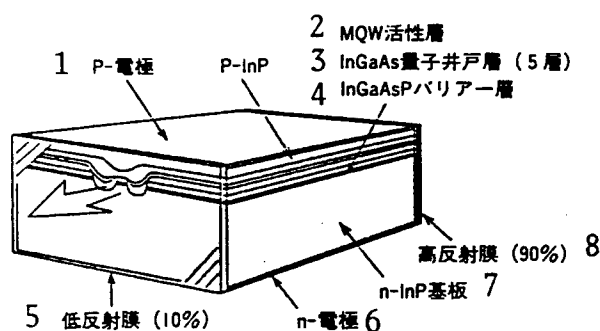


Figure 5. InGaAs MQW-DC-PBH LD

Key:—1. P electrode—2. MQW active layer—3. InGaAs quantum well layer (5 layers)—4. InGaAsP barrier layer—5. Low reflecting film (10 percent)—6. n-electrode—7. n-InP substrate—8. High reflecting film (90 percent)

The semiconductor laser to be presented next is the multiple quantum well laser diode (MQW-LD) reported by NEC Corp. The sectional structure of this device is shown in Figure 5. This device has an active layer of the double channel planar buried heterostructure, with five layers of InGaAs/InGaAsP MQW. The metal organic vapor phase epitaxy (MOVPE) method is employed for crystal growth. With the MQW structure, it becomes possible to lower the oscillation threshold (I_{th}) through reduction of the light absorption loss in the interior of the resonator, and a device with a long resonator is realized. In Figures 6 and 7, the L-I characteristics of devices with resonator lengths of 800 μm and 1,800 μm are shown. At 20°C, maximum outputs of 175 mW and 250 mW are obtained, respectively. In addition, in the APC test for high output operation at 100 mW, a mean deterioration rate of $2.8 \times 10^{-6}/\text{hour}$ is obtained for 2,700 hours.

As a semiconductor laser for this excitation wavelength band, there is the 1.47 μm graded-index separate confinement heterostructure single quantum well (GRIN-SCH SQW) LD reported recently by Furukawa Electric Co., Ltd. Its device structure is shown in Figure 8. The crystal growth method is MOVPE, and it has a GRIN-SCH structure obtained by sandwiching a 5-nm-thick single quantum well (SQW) of GaInAs with GaInAsP, having a stepwise varied composition, to achieve lattice matching with InP. Its device characteristics are I_{th} of 19 mA and an output of 100 mW for a resonator length of 900 μm (Figure 9). One feature of the laser with this structure is that the temperature change of the oscillation wavelength is very small compared with that of a laser diode with a bulk active layer (Figure 10).

2.2 0.98 μm Band Semiconductor Lasers

An EDF absorption wavelength band exists in the 0.9-1.1 μm wavelength band which could not be realized by the conventional GaAs and InP semiconductor lasers. This wavelength is 0.98 μm . Recent energy band designs for compound semiconductors are making it possible to

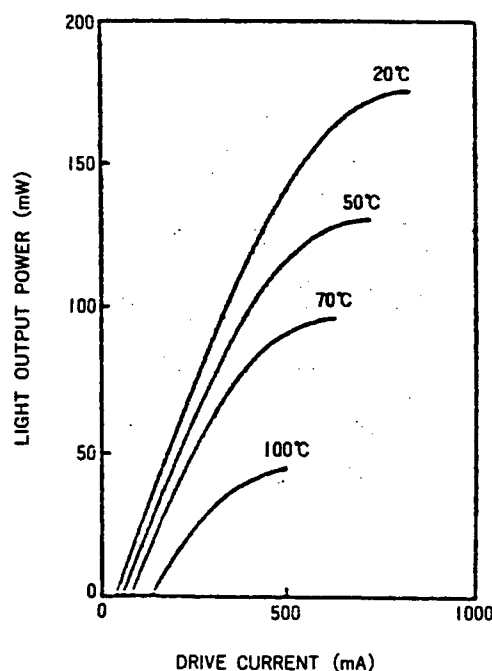


Figure 6. L-I Characteristics of InGaAs MQW-DC-PBH LD ($L = 800 \mu\text{m}$)

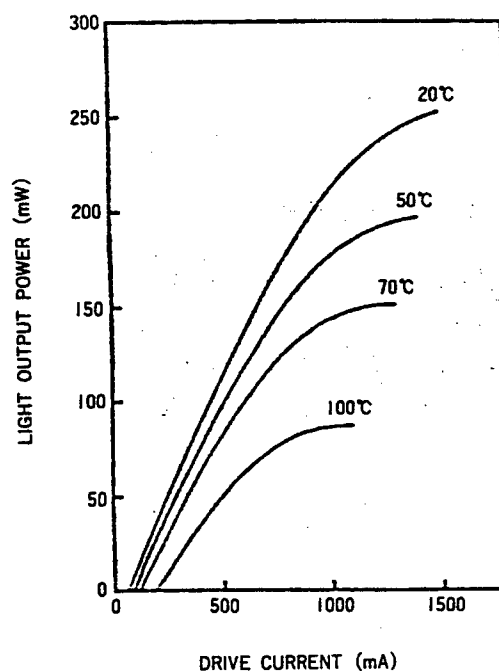


Figure 7. L-I Characteristics of InGaAs MQW-DC-PBH LD ($L = 1,800 \mu\text{m}$)

realize laser oscillation devices at wavelengths which were not possible to achieve with lattice matching systems. This technique is energy band structure engineering (EBSE).

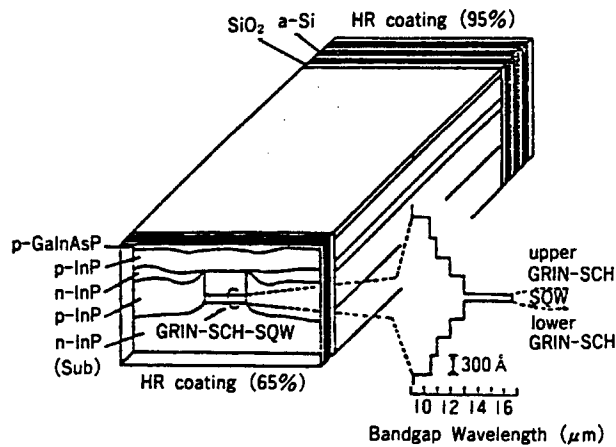


Figure 8. GRIN-SCH-SQW LD

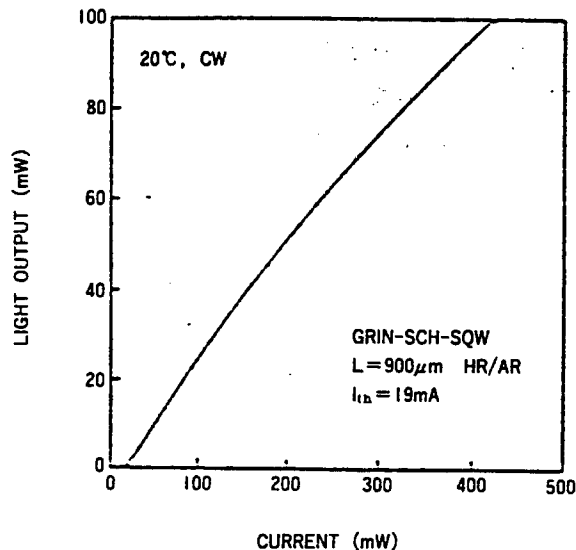


Figure 9. L-I Characteristics of GRIN-SCH-SQW LD

Viewed from the standpoint of EDFA, this wavelength is characterized by high efficiency while, at the same time, its absorption wavelength band is narrow (about 5 nm), so an interesting attempt to deal with this difficulty has been made using device fabrication technology.

The semiconductor lasers presented here for the excitation of the 0.98 μm wavelength band all employ a quantum well structure to carry out strained quantum well (SQW) device designs which actively utilize EBSE. It should be noted that there is a delicate difference in band structure design between these and the semiconductor lasers described in the previous section, although both use GaAs as the substrate.

First is NTT's strained single quantum well (SSQW) structure laser. Its device structure is shown in Figure 11.

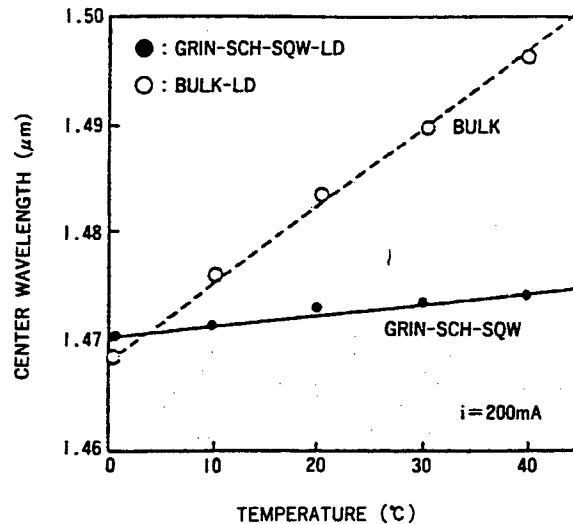


Figure 10. Temperature of Oscillation Wavelength of GRIN-SCH-SQW LD

MOVPE is employed as the crystal growth method. On a N-type GaAs substrate, a N-type buffer layer, a N-type $\text{Al}_{0.6}\text{Ga}_{0.4}\text{As}$ cladding layer, a GRIN layer, an $\text{In}_{0.2}\text{Ga}_{0.8}\text{As}$ SSQW active layer, an upper GRIN layer, a P-type $\text{Al}_{0.6}\text{Ga}_{0.4}\text{As}$ cladding layer and an uppermost P-type GaAs cap layer are grown sequentially, and then a cap layer and a cladding layer in the upper layer are etched in order to form a ridge-type waveguide. Then, electrodes are formed and face end reflectivity control processing is carried out. Its device characteristics are reported to be an I_{th} of 15 mA and a maximum output of 85 mW, for a high output laser diode with resonator length of 600 μm (Figure 12). Its characteristic temperature T_0 is 107 K, which is in between the values of the ordinary GaAs system QW-LD and the 1.55 μm band QW-LD. In addition, a current conduction of up to 5,000 hours has been reported as reliability data.

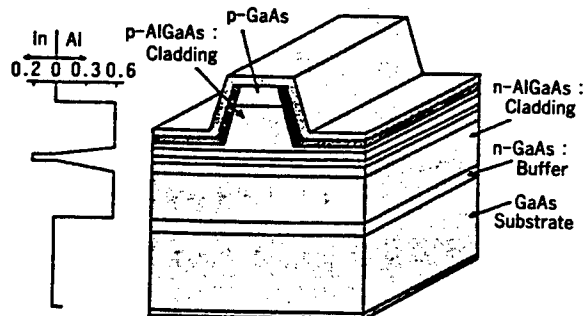


Figure 11. Ridge Waveguide Type SSQW LD

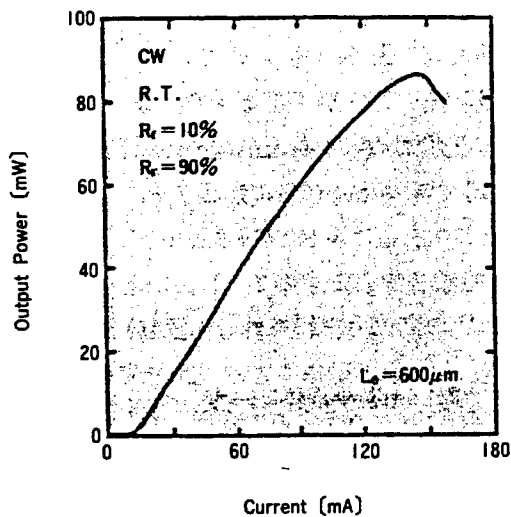


Figure 12. L-I Characteristics of SSQW LD

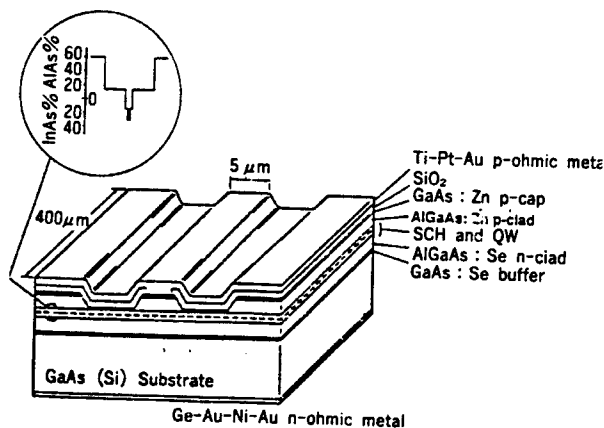


Figure 13. SSQW-SCH-InGaAs/AlGaAs LD

The following is a report on the SSQW-SCH-InGaAs/AlGaAs laser diode announced by the David Sarnoff Research Center of the United States (Figure 13). MOVPE is employed as the crystal growth method. Its structure starts with a N-type GaAs substrate, followed by a GaAs buffer layer, a N-type $\text{Al}_{0.6}\text{Ga}_{0.4}\text{As}$ cladding layer, an $\text{Al}_{0.15}\text{Ga}_{0.85}\text{As}$ waveguide layer region, a 60 Å thick $\text{In}_{0.25}\text{Ga}_{0.75}\text{As}$ SQW active layer sandwiched by an $\text{In}_{0.1}\text{Ga}_{0.9}\text{As}$ layer (40 Å), with stepwise controlled composition placed at the center of the waveguide layer, while a P-type $\text{Al}_{0.6}\text{Ga}_{0.4}\text{As}$ cladding layer and a P-type cap layer are grown sequentially, and the device is formed by carrying out ridge machining, electrode formation and end face processing. Figure 14 shows the L-I characteristics of the laser diode with a resonator length of 400 μm. It has been reported that I_{th} is 8 mA, the maximum output is 125 mW and T_0 is 143 K.

Another laser diode in this wavelength band is the pseudomorphic InGaAs/GaAs/AlGaAs SQW laser

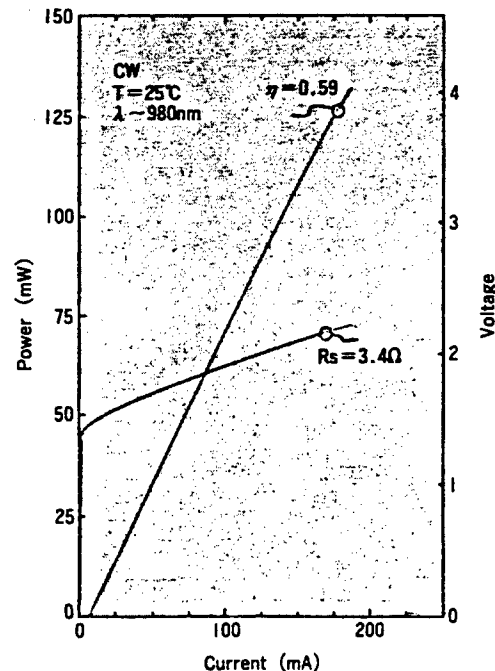


Figure 14. L-I Characteristics of SSQW-SCH-InGaAs/AlGaAs LD

diode, a kind of strained quantum well device, reported by California Institute of Technology. In Figure 15, its device structure and the composition profile of the quantum well portion are shown. This third example of laser diodes has a composition profile which is a synthesis, so to speak, of the structures of the previous two examples. The crystal growth method employed is molecular beam epitaxy (MBE). The basic device structure is GRIN-SCH. The active layer is an $\text{In}_{0.2}\text{Ga}_{0.8}\text{As}$ SQW (60 Å) layer which is sandwiched by 50 Å thick GaAs layers. The AlAs composition is increased by 5 to 50 percent by means of an AlGaAs GRIN layer to match AlGaAs. Its device structure is that of a ridge-type laser diode obtained by mesa etching. Its laser characteristics for an end face processed device

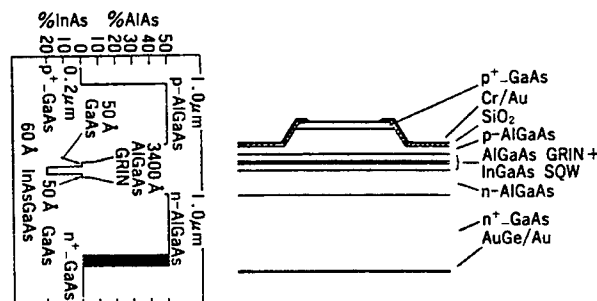


Figure 15. Pseudomorphic InGaAs/GaAs/AlGaAs SQW LD

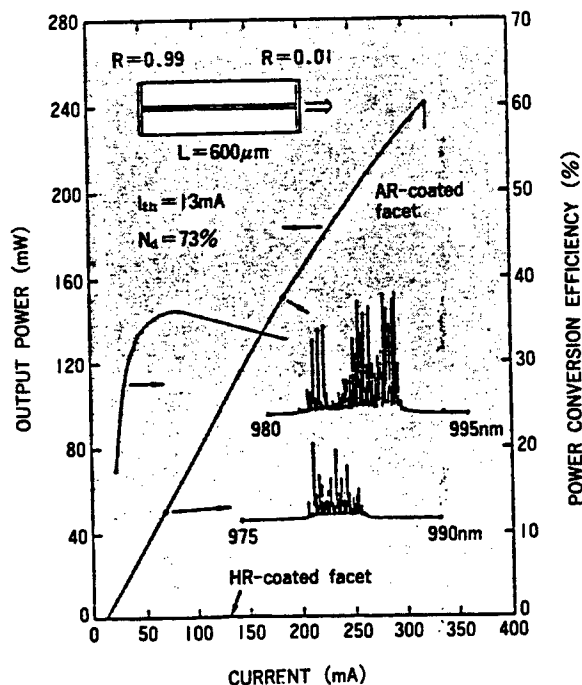


Figure 16. L-I Characteristics of Pseudomorphic InGaAs/GaAs/AlGaAs SQW LD

with a resonator length of 600 μm are I_{th} of 13 mA and a high maximum output of 240 mW (Figure 16).

2.3 0.8 μm Band Semiconductor Lasers

For this wavelength band, reports have been made on the use of inexpensive and high output GaAlAs system semiconductor lasers, namely, the so-called short wavelength laser diodes, as the pumping sources. However, as opposed to the two excitation wavelengths described above, the use of this wavelength results in problems in obtaining high gain due to the existence of ESA. In other words, the EDFA in this wavelength band requires innovations not in the pumping sources, but in the amplification systems employing fibers, including EDF. It is well known that the developmental history of 0.8 μm -band laser diodes as light sources goes back further into the past than does that of devices of long wavelength bands. Accordingly, it can be said to be significant that lasers in this wavelength band demonstrate excellent reliability and profitability as pumping sources.

The last to be reported are those announced by NTT. Two experimental examples will be presented.

First, a laser has been reported whose gain has been improved by realizing population inversion over the entire length of EDF through application of the excitation system from both directions. The construction of the EDFA is shown in Figure 17. The pumping source is the 0.817 μm high output GaAlAs laser diode. In order to increase the EDF coupling, excitation is carried out

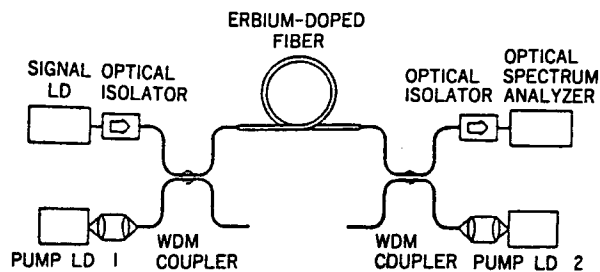


Figure 17. 0.82 μm DFA by Bidirectional Excitation System

from both directions using a wavelength demultiplexing and multiplexing (WDM) coupler. The coupling efficiency for the excitation light and signal light of this coupler is 97 percent. The dependence of the gain on the pumping input for a signal light of 1.535 μm is shown in Figure 18. The pumping power in the figure shows the sum of the powers from both directions. It can be seen that a gain of 21.6 dB is obtained for an excitation input of 53 mW. In addition, a maximum gain of 29.4 dB is reported for a higher excitation input of 83 mW.

Another laser reported is an EDFA that uses a commercially-available CD GaAlAs laser diode (oscillation wavelength of 0.815 μm) as a pumping source. Its structure is shown in Figure 19. Beams of light from two laser diodes are multiplexed and are then coupled with a signal light, which is input to the EDF as a pumping source. Its amplification lacks linearity somewhat, as is shown in Figure 20, but a maximum gain of 32 dB has been reported for an excitation input of 55 mW.

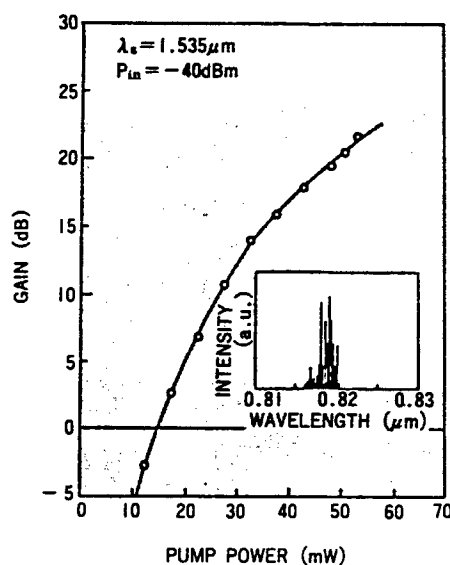


Figure 18. Gain-Input Characteristics of 0.82 μm DFA by Bidirectional Excitation System

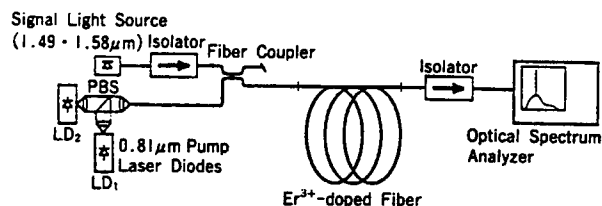


Figure 19. Block Diagram for EDFA Excited by 0.8 μm Band LD

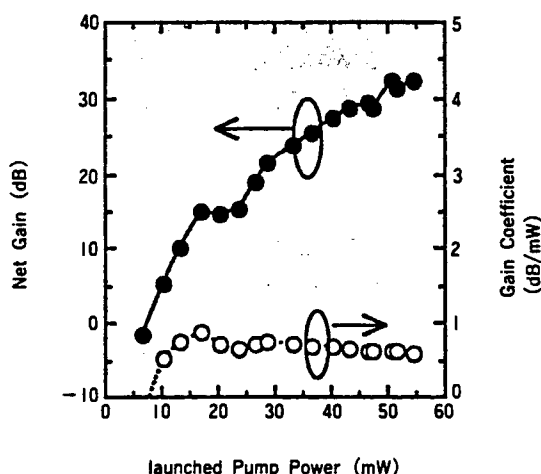


Figure 20. Amplification Performance of EDFA Excited by 0.8 μm Band LD

3. Conclusion

In the foregoing, the status of recent research is reported concerning the pumping sources for the EDFA. A survey indicates the necessity of enhancing the performance and reliability of the EDFA elements by semiconductor laser diodes. As it stands, 1.48 and 0.98 μm are considered to have become the mainstream of the excitation wavelengths.

These two wavelengths will be included in the EDFA systems in forms that make active use of the characteristics of the respective pumping sources. It is believed that the 1.48 μm pumping source, whose performance is highly reliable, will be applied to booster amplifiers and in-line amplifiers, while the 0.98 μm pumping sources will be applied to preamplifiers due to their high efficiency and low noise characteristics.

It has been reported recently that the EDFA's are suitable for applications not only to optical communications and coherent communication systems by ordinary intensity modulation, but also to optical soliton transmission by using ultrashort optical pulses, etc., and it is believed that, since it is an important technology for optical fiber communications, the speed of future advancements should be increased.

Applications of Er-Doped Fiber Amplifiers to Optical Communications Systems

916C0013D Tokyo OPTRONICS in Japanese Nov 90
pp 67-74

[Article by Kiyoshi Nakagawa and Kazuo Hagimoto, NTT Transmission Systems Laboratories]

[Text]

1. Introduction

Optical transmission technology has advanced to the point that locations all over Japan are connected by networks of optical communications systems, and the trunk transmission routes have entered the era of 1.6 gigabit large bundle transmission. In addition, optical transmission technology has begun to be applied to local area networks and subscriber networks. These are accomplished by making active use of the wide band and low loss properties of the optical fibers comprising the transmission routes, and by replacing the existing copper cables with optical fibers and expanding the areas covered by optical fibers. On the other hand, in each component of optical communications systems, since the processing of optical signals is always executed after their conversion to electrical signals, the system configuration has continued to add an optoelectric conversion part to the electrical signal processing part. However, along with the popularization of optical transmission technology, there has been an increasing demand for transferring, processing, etc., optical signals as they are. That is, the necessity for amplifying signals as they are, which is quite natural for electrical signals, has arisen for light. This means that optical technology has become familiar to us. Such optical amplification has been the dream of optical transmission engineers and has been studied since olden days, but it has never led to the realization of a practical optical amplifier. However, the erbium-doped optical fiber amplifiers (EDFA's) that have been investigated actively in recent years are drawing attention for their advantages involving ease of connection with single mode fibers that comprise transmission routes and their polarization independence. In fact, the realization of a semiconductor laser-excited erbium-doped fiber amplifier with high applicability, and the successful repeaterless 212 km transmission at 1.8 Gb/s by utilizing the amplifier, aroused a boom in research on erbium amplifiers and on the transmission systems employing the amplifiers. This was accomplished by removing a factor, called loss, which had been restricting the performance of previous optical communications systems, and optical communications systems could then be constructed in a dynamic manner due to the fact that the EDFA's have a high gain fiber to fiber (30 dB) and low noise, and easily provide a stable and high performance, free from polarization fluctuations, over a wide band. In addition, stimulated by the above-mentioned success, the characteristics of semiconductor-type optical amplifiers have also been improved. In this review, the applications of these optical amplifiers to optical communications systems will be described, focusing on recent accomplishments.

Table 1. Comparison of Various Kinds of Optical Amplifiers

		Amplifiers				
				1	2	3
		FP-LD	TW-LD	Erファイバ	ラマン	ブリルアン
4	信号利得 (dB)	20-35	20-30	30-50	20-50	30-50
5	帯域 (Hz)	1-3 G	3-20T	0.5-10T	~1 T	~50M
6	飽和出力 (dBm)	-10	0-10	0-10	20	
7	ファイバ結合効率	3-5	3-5	0-1	0-1	0-1
8	長さ (m)	200-500 μ	200-500 μ	10-100	~20k	~20k
9	電流/光励起パワー	30mA	200mA	20-100mW	0.5-2 W	~50mW
10	偏波依存性	12大	大	13無い	大	大
11	安定性	×	△	◎	○	△

Key:—1. Er Fiber—2. Raman—3.Brillouin—4.Signal gain (dB)—5.Band (Hz)—6.Saturated output (dBm)—7.Fiber coupling efficiency—8.Length (m)—9.Current/optical excitation power—10.Polarization dependence—11.Stability—12. High—13.None

2. Characteristics and Uses of Optical Amplifiers

Similar to ordinary electrical amplifiers, optical amplifiers can be described in terms of their characteristics, and the required characteristics are naturally similar to those of electrical amplifiers. These parameters include the gain characteristic, band characteristic, noise characteristic, saturated output, stress characteristic, efficiency, shape, etc. The parameters that have been examined so far for various optical amplifiers are compared in Table 1. The investigation of fiber amplifiers has long been done as part of fiber laser research, but its efficiency was low. Then, system application oriented research was initiated for basic investigation purposes by employing other semiconductor lasers or nonlinear optics. However, optical amplifiers that utilize nonlinear optical effects have low excitation efficiency, and since semiconductor amplifiers are stable with regard to polarization dependence, problems involving coupling with fibers, the influence of the Fabry-Perot mode, etc., they were retained for basic investigations. With the appearance of stable optical amplifiers, called EDFA's, research on optical amplifiers has moved to the center of the R & D on optical communications systems.

Since optical amplifiers amplify optical signals directly, their uses can be classified into preamplifiers (low noise amplifiers), booster amplifiers (intermediate amplifiers) and post-amplifiers (power amplifiers), similar to those of electrical amplifiers. Figure 1 gives a block diagram for applications. As for loss compensation, both the transmission loss and the branching loss can be handled on the same footing.

The noise figure is a parameter that requires attention when using optical amplifiers. Figure 2 is the signal spectrum after an input signal light is amplified by an optical

amplifier. For any optical amplifier, a spectrum of spontaneously emitted light is added after amplification. The noise found in the demodulated light consists of the spontaneous-spontaneous beat noise whose frequency components are within the base signal band and the signal-spontaneous beat noise. When the former noise is removed sufficiently to be at a negligible level by a narrow band optical filter, the noise factor of the amplifier can be represented by $NF = 2n_{sp}$, where n_{sp} is the population inversion parameter, which is the factor that determines the noise characteristics of the optical amplifier. For an ideal optical amplifier, the population inversion parameter approaches unity and the noise figure becomes 3 dB. In other words, the direct application of such a low noise amplifier to the detection system suggests that the reception sensitivity can be improved by reducing the thermal noise limit to a level which is 3 dB lower than the shot noise limit, and a sensitivity equal to or better than that of the heterodyne detection system can be expected. What is important in this connection is the reduction in the loss

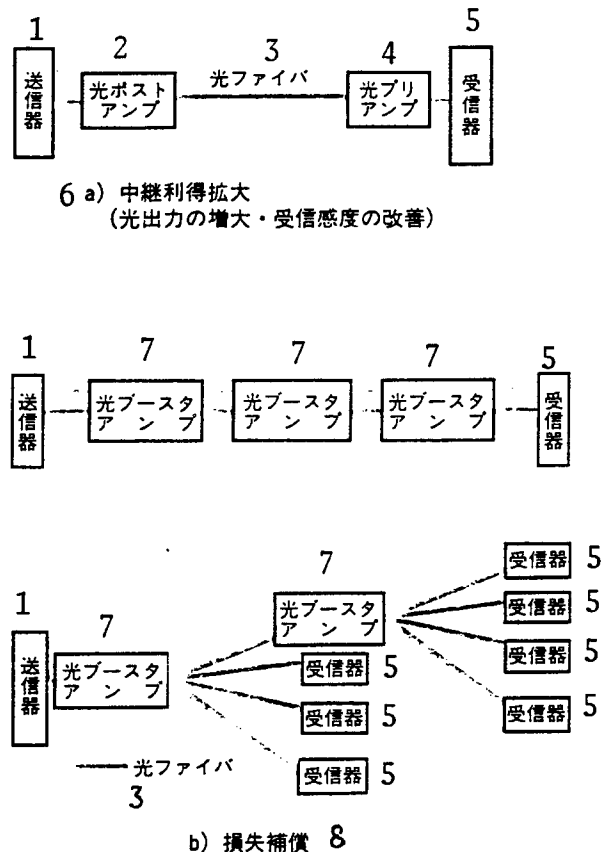


Figure 1. Block Diagram of Optical Amplifier Applications

Key:—1. Transmitter—2. Optical post-amplifier—3. Optical fiber—4. Optical preamplifier—5. Receiver—6.a) Repeater gain expansion (increase in optical output, improvement of reception sensitivity)—7. Optical booster amplifier—8.b) Loss compensation

due to coupling to the optical amplifier and a narrow band optical filter for removing the spontaneous emission. In this respect, a fiber amplifier can be coupled to an optical fiber, forming the transmission path, and, since its gain is sufficiently high, it can tolerate the loss due to the optical filter. The effect of the optical filter can be realized more easily when the bit rate is high. This means that, in keeping with the wide bandwidth of the optical amplifier, an advantage of the optical filter is the ease with which it can achieve higher speed. For example, Figure 3 shows the spectrum of spontaneous emission for a pure silica cored EDFA. The 3 dB bandwidth in the vicinity of $\lambda = 1.536 \mu\text{m}$ is approximately 130 GHz (1 nm). This bandwidth is comparable to that of a narrow band optical filter, and it is thought that low noise amplification can be achieved without the use of an optical filter and that its modulation band is sufficiently large, at several dozen gigabits per second. Moreover, it has a gain of more than 35 dB, as shown in Figure 4, and, therefore, the noise figure is low, at 5.5 dB. Another important characteristic, i.e., optical output, should be mentioned here. As shown in Figure 4,

saturation of the gain begins to appear in the vicinity where the optical output exceeds 0 dB. This means that, by including the saturated region, a light signal with more than +10 dBm is obtained within the fiber, making this device promising also as a post-amplifier. That an EDFA is suitable also as an optical amplifier for power amplification is due to the fact that the gain variation of the optical amplifier has the large value of about 10 ms, making it usable also in heavily saturated regions without having any pattern effect on the high speed optical pulse trains. From the above description, it can be said that EDFA's are expected to have excellent characteristics for both pre-amplifiers and post-amplifiers and, hence, are promising as booster amplifiers that demonstrate aspects of both pre- and post-amplifiers. In other words, EDFA's are expected to be employed for every use. Recently, enhancements in the performance and expansion of the application region have been in progress, such as the attainment of the theoretical limit of $\text{NF} = 3 \text{ dB}$ and the expansion of the band to about 10 nm by co-doping Al_2O_3 into the core (Figure 5).

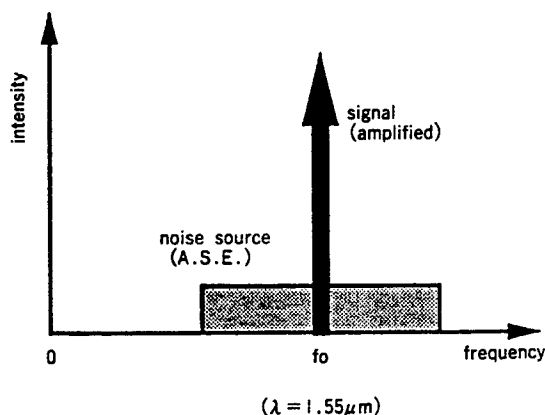
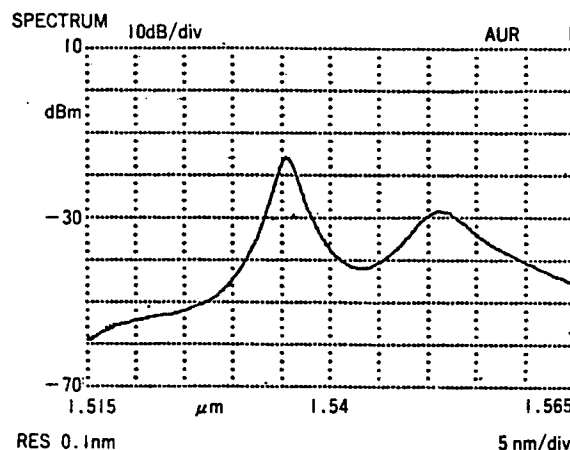
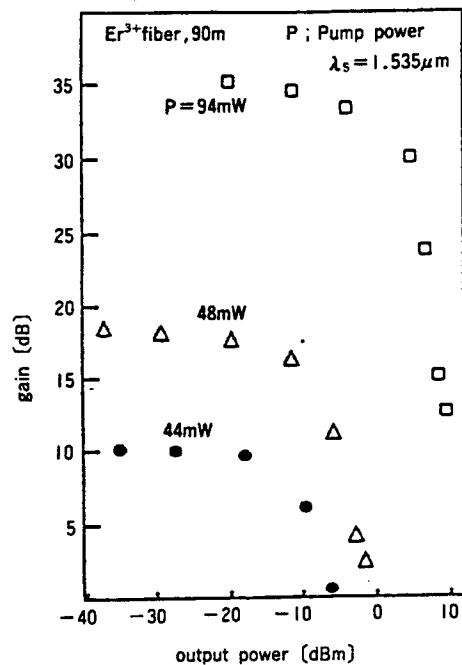


Figure 2. Output Signal Spectrum of Optical Amplifier

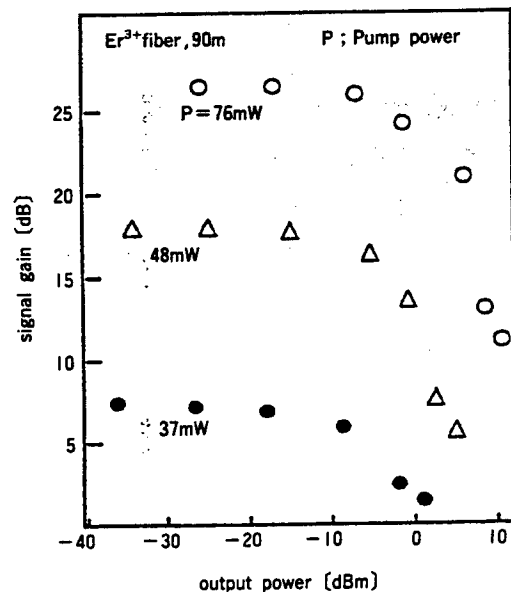


1 EDFAのASEスペクトル特性
(励起パワー=76mW)

Figure 3. Spontaneous Emission Spectrum of Pure Silica Core EDFA
Key:—1. ASE spectrum characteristic of EDFA (excitation power = 76 mW)



1 (a)信号光波長: 1.535 μ m



2 (b)信号光波長: 1.554 μ m

3 信号利得の出力パワー依存性

Figure 4. Signal Gain Characteristics of Pure Silica Core EDFA

Key:—1.(a) Signal light wavelength: 1.535 μ m—2.(b) Signal light wavelength: 1.554 μ m—3. Output power dependence of signal gain

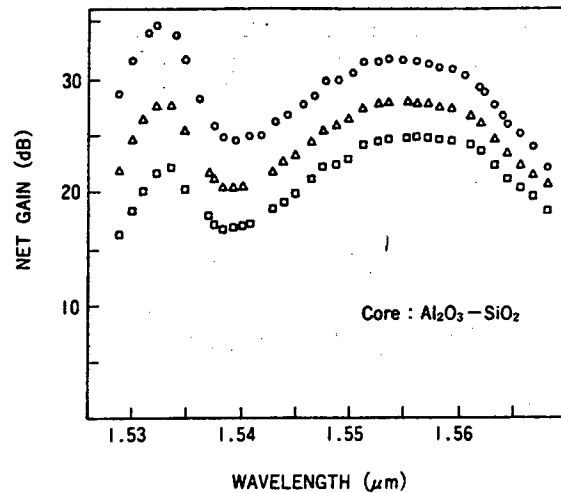


Figure 5. Wavelength Dependence of Gain for Aluminum Co-Doped EDFA's

3. Examples of System Experiments Using Optical Amplifiers

3.1 Applications to Trunk Transmission Systems

(a) Large Capacity and Long Span Repeaterless Transmission

In order to increase the repeater spacing, it is necessary not only to improve the reception sensitivity, but also to increase the transmission power. For this reason, optical post-amplifiers are used in the transmission part to compensate for losses in the modulator, etc., and to expand the optical transmission output, and optical pre-amplifiers and a wide-band PIN-PD are employed at the reception part. With the above structure, the repeater spacing is approximately doubled in the gigabit region for the intensity modulation/direct detection system by the use of EDFA's in comparison with the conventional LD direct modulation and APD direct detection scheme. In addition, it has been possible to increase the transmission speed by utilizing the wide band nature of the EDFA's. Figure 6 shows an experimental system for a 17 Gb/s and 150 km repeater spacing transmission. In this system, distributed compensation is also carried out in the receiver. The reception sensitivity in this case is a satisfactory value of -25.8 dBm. Figure 7 gives examples of a repeaterless transmission for direct and coherent detection systems. The effectiveness of optical amplifiers (NTT's data all for EDFA's) is clearly demonstrated in the figure. Then, using a post-amplifier in the coherent-type transmitter, the transmission power is increased to +20 dBm and the repeaterless distance is extended to 364 km for 2.5 Gb/s.

The repeater spacing can also be increased by a system in which an erbium-doped fiber alone is placed in front of the receiver, and is then remotely excited from the receiver. Figure 8 is its block diagram. The location of

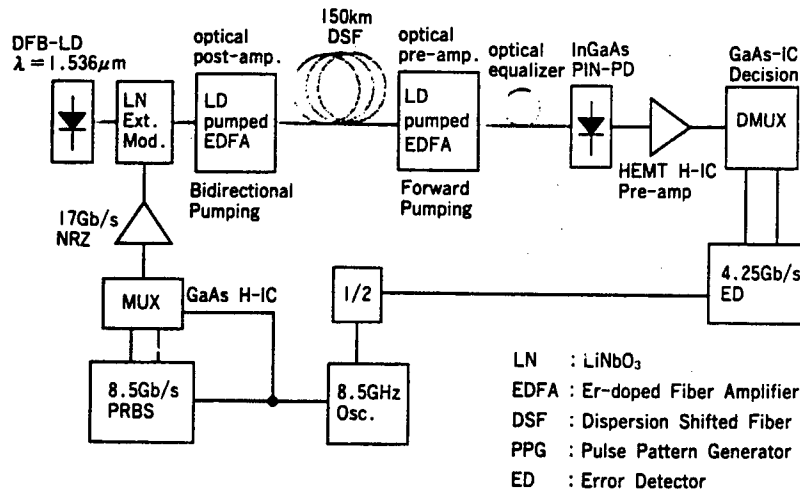


Figure 6. Block Diagram of 17 Gb/s, 150 km Transmission Experiment

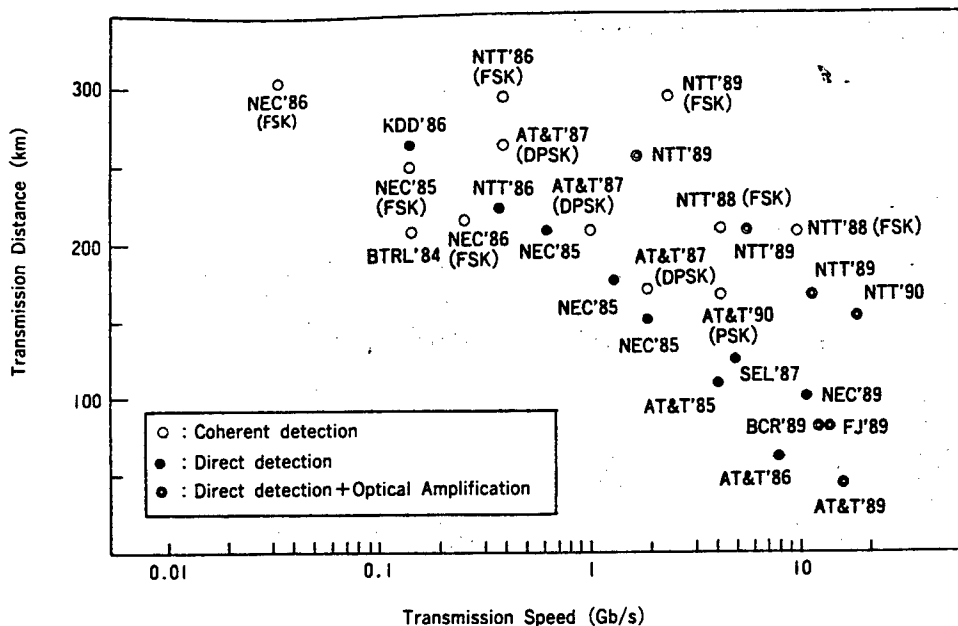


Figure 7. Repeaterless Transmission Experiment Trend

the erbium-doped fiber is also regarded as the location of the receiver, and it is possible to extend the repeater spacing by the length of the segment behind it. This is possible because energy transmission is available to the erbium-doped fiber, which is far from the receiver since the fiber, comprising the transmission path, has a low loss for the excitation light as well ($\lambda = 1.48 \mu\text{m}$).

(b) Linear Multirepeater Transmission

It is possible to use optical amplifiers as linear amplifiers and to carry out multirepeater transmission without

converting the light to electrical signals. Moreover, since linear repeaters do not depend on the bit rate, the transmission capacity can be changed simply by replacing the transmitter and receiver at both ends. Figure 9 demonstrates the application of the above-mentioned method to the direct detection system carrying out a 505 km transmission by means of five repeaters at 10 Gb/s. Figure 10 shows an example of applying the method to the coherent detection system, giving the reception characteristics for a 2200 km transmission with 25 repeaters at 2.5 Gb/s. Both cases demonstrate a transmission capability of approximately 5

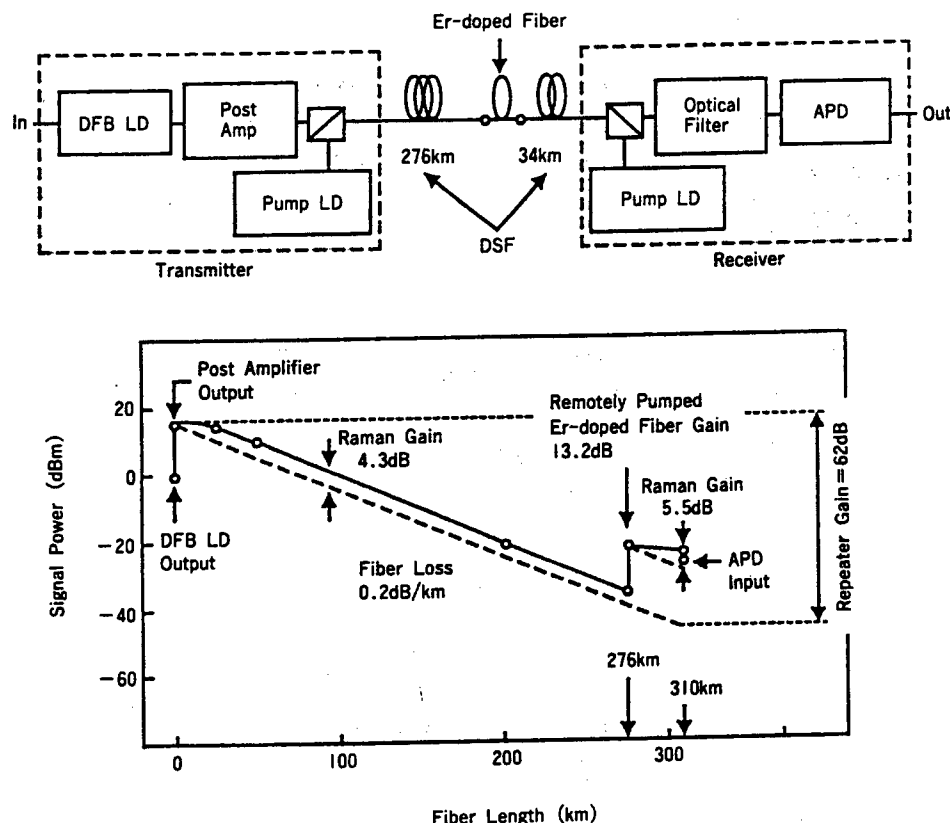


Figure 8. Block Diagram of Remotely Excited Transmission System

Tb/s·km, which is only possible when using linear amplifiers. In addition, optical soliton transmission has become realizable by using optical amplifiers to compensate for the transmission loss path.

3.2 Application to Signal Distribution System

In order to distribute signals to a large number of users, the use of booster amplifiers and post-amplifiers formed from optical amplifiers in subcarrier analog transmission systems and optical FDM systems is being examined.

Figure 11 shows the CNR characteristics for a six-stage EDFA transmission by directly modulating a 1.552 μm DFB-LD with a subcarrier system of an AM-FDM or an FM-FDM analog signal. The graph shows that the signal still secures the desired CNR, even after multiple-stage repeating, and is sufficiently applicable to distribution systems. In addition, although it has been necessary to increase the bandwidth in the optical FDM application,

success has been reported regarding a 100-wave batch amplification, as shown in Figure 12, by expanding the band to about 10 nm by using aluminum co-doped EDFA's. As in the above, since EDFA's enable low distortion or low crosstalk amplifications, they are extremely effective for branching loss compensation in analog systems or multiwavelength transmission systems.

4. Conclusion

Erbium-doped fiber amplifiers are circuits with various characteristics that are precisely suited to the advancement of optical communications systems, convincing us that they will be used in extremely wide fields of optical communications. It is believed that the performances of the optical amplifiers themselves will advance further, but the largest tasks involved in putting them into systems in the future will be enhancing the reliability and profitability of the optical amplifiers.

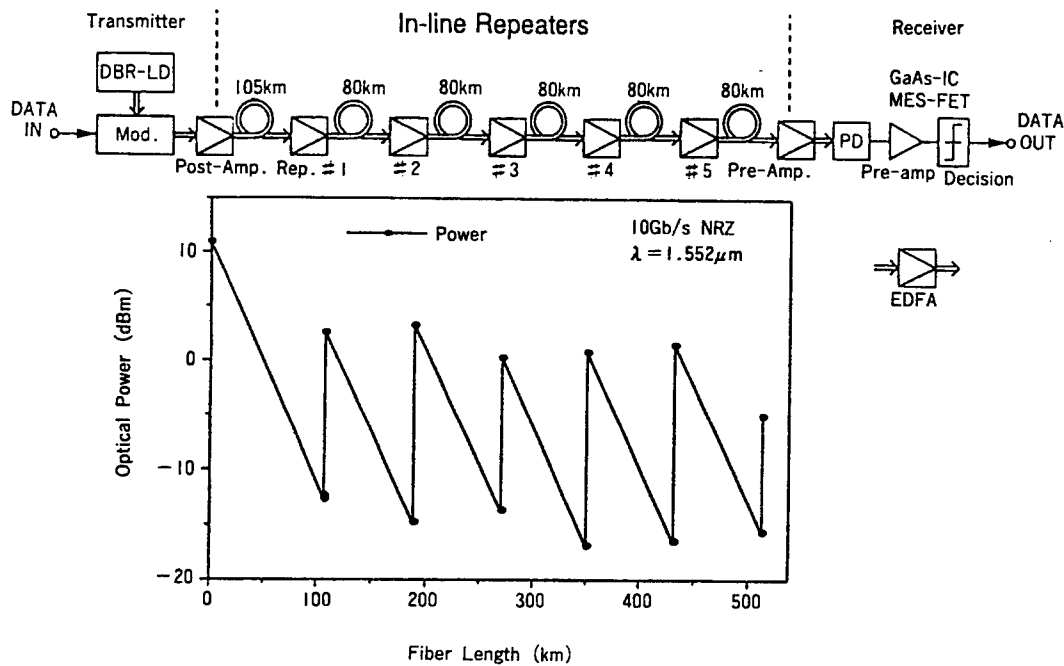


Figure 9. 10 Gb/s Multirepeater Transmission System

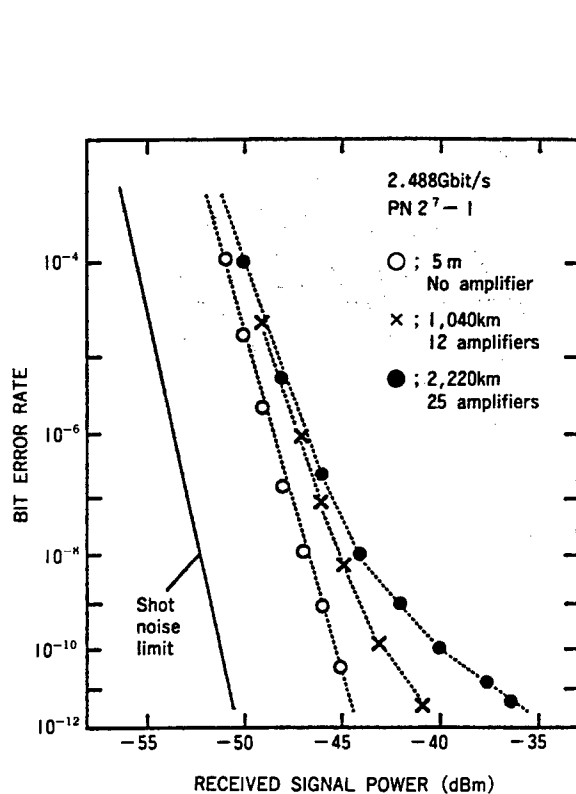


Figure 10. Transmission Characteristics of Coherent Multirepeater Transmission

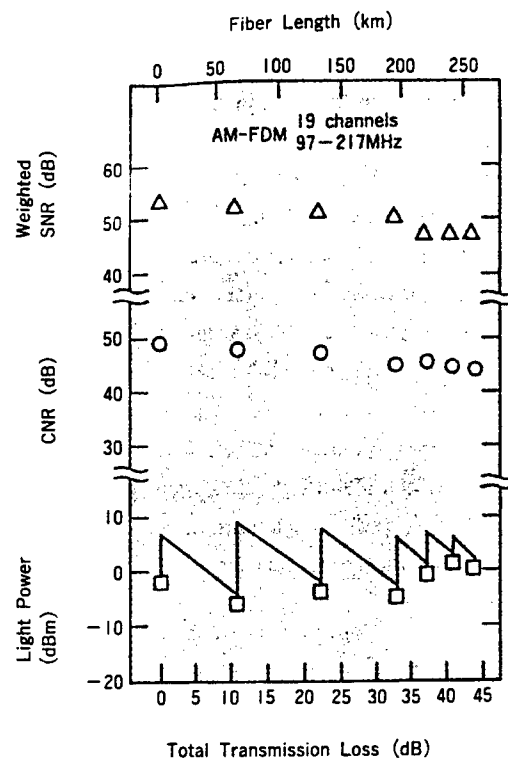


Figure 11. CNR Characteristics for Six-Stage Multiple-Repeater Transmission

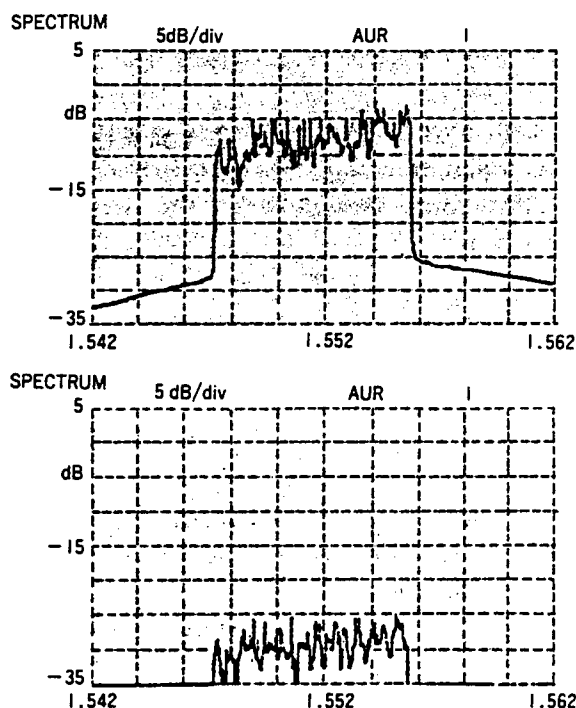
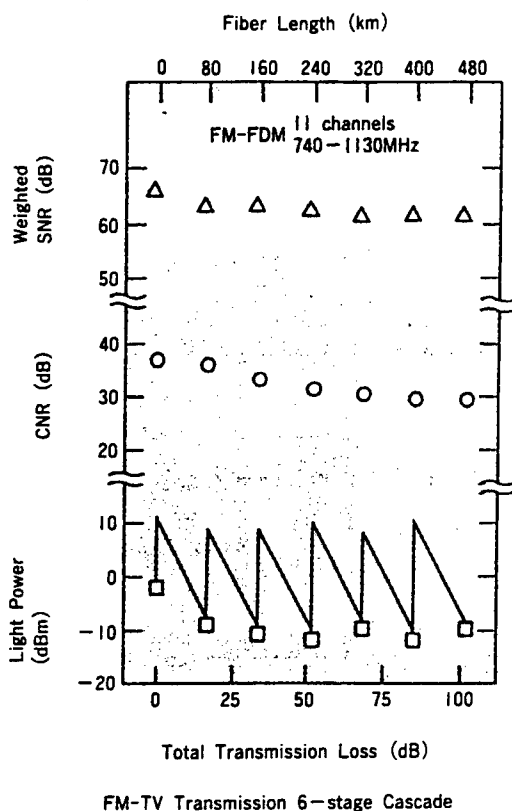


Figure 12. 100-Batch Optical Amplification

NTT Develops Optical Transistor

General Description

91P60205A Beijing ZHONGGUO DIANZI BAO
[CHINA ELECTRONICS NEWS] in Chinese
29 May 91 p 3

[Article by Chen Yousong [7115 1635 2646]: "New Optical Transistor Developed: Opens New Paths Toward Realization of an Optical Computer"]

[Summary] NTT recently developed an optical transistor, a device used to form optical logic gates, i.e., logic gates using only light (as opposed to electricity) as the working medium. The operating principle is that light incident onto an EARS (surface-type optical switch) device is reflected off the device, and the optical power of the reflected (output) light is read out—as a "1" for higher-power light and as a "0" for lower-power light, thus realizing 1-bit digital optical signal processing. Onto a 3-mm-diagonal chip, 64 of the newly developed EARS devices—corresponding to 64 bits—have been integrated; moreover, the AND, OR, and other basic logic operations have been demonstrated using only light sources and the new devices. These new optical transistors can be used to process 1-terabit-and-higher high-capacity information.

NTT's EARS device has a structure consisting of three overlapping layers: a quantum-trap layer, a reflecting layer, and a light-sensitive layer, all made from GaAs and AlGaAs. A major feature of the new device is that the power of the output light can be amplified up to 100 times; i.e., the device has a gain or amplification factor of up to 100. Other specifications of the device are as follows: sensitive wavelength = 0.85 micron (near-IR), and switching time for a 100-μW optical control signal is 20 nanoseconds (ns), easily reducible to 1 ns or lower.

Prior to this development, optical transistors used optically bistable devices and SEEDs [self-electro-optic-effect devices]. NTT's new optical transistor will have important applications in optical communications and optical computing.

Additional Details

91P60205B Beijing JISUANJI SHIJIE [CHINA
COMPUTERWORLD] in Chinese No 21,
29 May 91 p 41

[Unattributed article: "NTT Develops Optical Transistor"]

[Summary] NTT's newly developed optical transistor, which will have applications in 1-million-instructions-per-second optical computers and in ultra-high-speed (1Mbit/s) photonic switching systems, has a diameter of 100 microns and a thickness of 10 microns; 64 of the new devices have been integrated onto a base plate with 3-mm-long sides. The new transistor consists of three overlapping layers, among which the light-absorption layer—critical to the light-control process—has a multi-quantum-well composition.

Development of Acoustic Support System for Shinkai 6500

916C0019A Tokyo BOEI GIJUTSU in Japanese Dec 90 pp 31-42

[Article by Hisami Hayakawa, Hideyuki Takahashi, Ieharu Kaihou, Kazuo Barada and Hirofumi Takahashi; Oki Electric Co., Ltd.]

[Text]

Abstract

The underwater investigation vessel Shinkai 6500, developed by the Oceanic Science and Technology Center, has set the current world depth record of 6,527 meters for submarines in sea experiments. In order for submersibles to conduct investigative activities both safely and effectively in dark waters 6,500 meters below the surface, it is extremely important to know the current position of the submarine and to detect and evade obstacles ahead.

As a support system for Shinkai 6500, Oki Electric Co., Ltd. has developed an acoustic navigation device that enables the submarine vessel to be monitored and tracked from the mother ship, an integrated control display device, an acoustic monitoring device for use by the submarine vessel to obtain its position, and observation sonar to detect and visualize obstacles and objects ahead.

1. Introduction

The Shinkai 6500, constructed according to the Oceanic Development Commission's report entitled "Research and Development of 6,000-m Class Underwater Investigative Vessel Systems," has recently been completed and is ready for the Oceanic Science and Technology Center to begin operation. The Shinkai 6500, with diving capabilities of 6,500 meters, currently representing the world record for underwater investigative vessels, is a sophisticated vessel capable of investigating 98 percent of the world's oceans and approximately 96 percent of Japan's 200-mile economic zone, and is expected to play an active role in the investigation of mineral resources, such as hydrothermal polymetallic ore and manganese nodules which have recently been found in succession, as well as in the underwater investigation of the Japan Trough, which is said to be an earthquake nest.

Here we shall outline the acoustic navigation device and the integrated control display device loaded on the supporting mother ship (mother ship) Yokosuka, and the acoustic monitoring device and observation sonar loaded on Shinkai 6500 (submarine), which were developed by Oki Electric Co., Ltd. under the direction of the Oceanic Science and Technology Center.

The acoustic navigation device is a system for monitoring, tracking and controlling the underwater vessel from the mother ship and for supporting underwater navigation operations, and Oki Electric Co., Ltd. was

given responsibility for its development following the development of the Shinkai 2000¹. The acoustic monitoring device, equipped for the first time, is loaded on the submarine and monitors its own position. The observation sonar is an ultrasonic imaging device used to observe obstacles ahead of the submarine, and was newly developed by Oki Electric to replace the CTFM sonar on the Shinkai 2000.

For this development, in addition to solving technical problems such as long-distance detection due to increased diving depths three times those of the Shinkai 2000, great functional improvements over the Shinkai 2000, including preventing falls in monitoring rates due to longer propagation delay times of sound waves and studying structures that could tolerate hydraulic pressures of 680 kgf/cm², were required. The characteristics, methods, major items, experimental results, etc., of these systems are outlined below^{2,3}.

2. Acoustic Navigation Device and Integrated Control Display Device

2.1 Device Outline

The configurations of the acoustic navigation device and integrated control display device are shown in Figure 1. The acoustic navigation device used to monitor the submarine and the integrated control display device used to display the monitored results, etc., are loaded on the mother ship, and three transponders, which serve as the monitoring reference, are set up on the sea bed. In addition, synchronous pingers for measuring its own position are loaded on the submarine.

The device is required to have the following capabilities:

- (1) In consideration of future operations, the ability to monitor at depths to 11,000 meters
- (2) The ability to monitor in the 45-degree range below the mother ship
- (3) High monitoring rates
- (4) High monitoring accuracy

In order to fulfill these requirements, the following measures were taken with regard to this device:

- (1) In order to enable long slant range measurement, in addition to using preformed beams with 16-element receiver arrays, the acoustic frequency has been made approximately half that of Shinkai 2000 (7.5 kHz band) to improve the S/N ratio.
- (2) Since the transponder method adopted for the Shinkai 2000 took time when measuring the propagation delay time and the monitoring rate fell, synchronous pingers have been loaded on the submarine and a method capable of monitoring with one-way propagation has been adopted.
- (3) Regarding unexpected malfunctions, there are two of each of the principal components, such as CPU's and

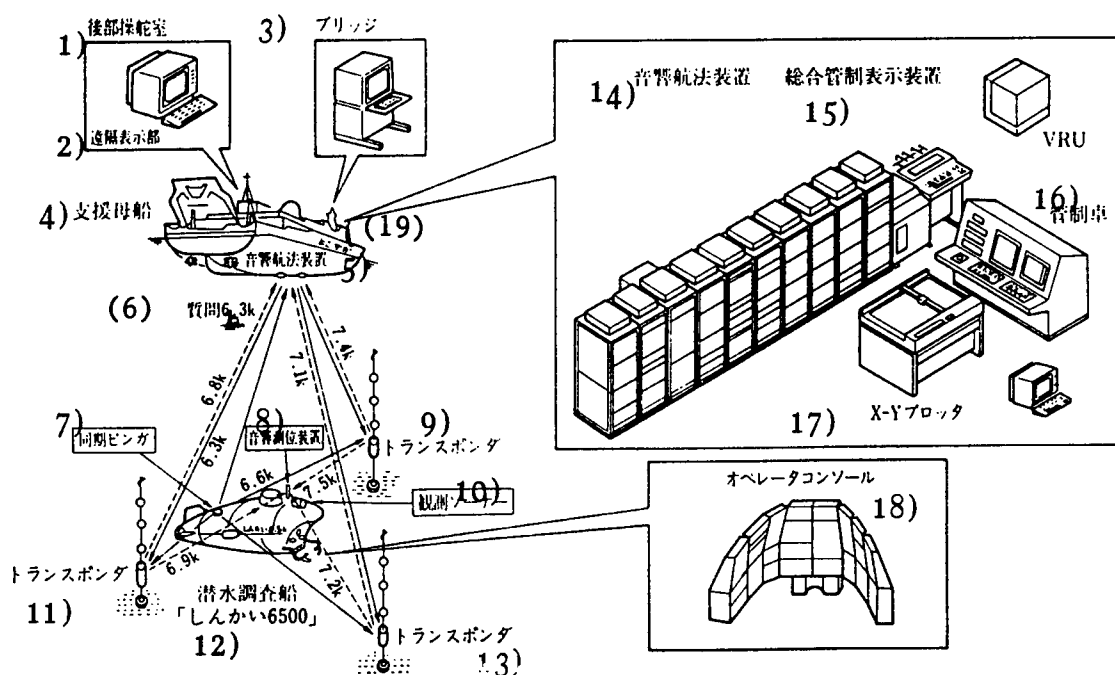


Figure 1. System Configuration

Key:—1. Rear steering house—2. Remote control display unit—3. Bridge—4. Support mother ship—5. Acoustic navigation equipment—6. Query 6.3K—7. Synchronous pinger—8. Acoustic monitoring equipment—9. Transponder—10. Observation sonar—11. Transponder—12. Underwater investigation vessel—13. Transponder—14. Acoustic navigation equipment—15. Integrated control display equipment—16. Control panel—17. X-Y plotter—18. Operator console—19. Yokosuka

synchronous pingers, making it possible to continue monitoring even if one of the two ceases functioning.

(4) In order to control the increase in monitoring errors caused by changes in the sonic speed in the sea accompanying depth changes, instead of using the average sonic speed of all depths, as has been done in the past, the layer sonic speed adjustment method has been adopted.

2.2 Monitoring Method

2.2.1 Adopting the LBL and SSBL Monitoring Methods

Acoustic monitoring methods are classified into the following three categories according to the length of the base line, as shown in Figure 2.^{4,5}

—LBL (Long Base Line) method

—SBL (Short Base Line) method

—SSBL (Super Short Base Line) method

The LBL is more accurate than the other methods, but three transponders are necessary for monitoring and operability is low. The SSBL method is lower in monitoring accuracy than the LBL, but monitoring requires

only one transponder and operability is high. The SBL method lies midway between these two methods in both accuracy and operability. This device adopts the LBL and SSBL methods, and each will be used accordingly.

This device must follow the submarine at depths of 6,500 meters and, in the future, it must also monitor the 11,000-meter class unmanned probes planned to engage in the rescue of Shinkai 6500. LBL monitoring, which is appropriate for such high accuracy monitoring in deep water, is carried out in the following order:

(1) Estimate position for location of transponders - transponder calibration.

(2) Measure the distance between the transponders and mother ship (slant range).

(3) Calculate the position of the mother ship from the three slant ranges.

2.2.2 Improving S/N Ratio with Preformed Beams

Conventional SSBL receiver technology was used to measure the slant range, and preformed beams were made with 16-element receiver arrays, improving the S/N ratio by 10-12 dB.

2.2.3 Synchronous Pinger Method and Two Cycle Transponders

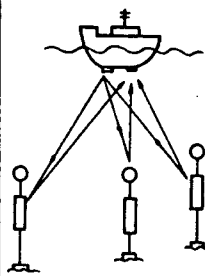
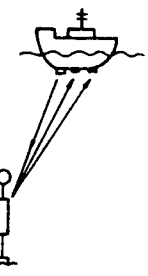
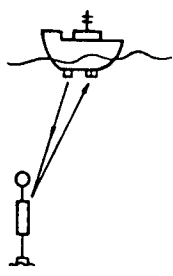
1)	方式	LBL	SBL	SSBL
2)	概念図			
3)	計測量	スラントレンジ 5)	伝搬時間差 7)	伝搬時間と位相差 9)
4)	特徴	高精度 キャリブレーション必要 6)	LBLより精度は悪いが トランスポンダ1本でよい 8)	LBLより精度は悪いが トランスポンダ1本でよい 8)

Figure 2. Comparison of Monitoring Methods

Key:—1. System—2. Conceptual diagram—3. Monitoring amount—4. Features—5. Slant range—6. High accuracy calibration required—7. Propagation time difference—8. Accuracy is worse than LBL but only one transponder is enough—9. Propagation time and phase differences

This device has made one-way propagation monitoring possible by loading synchronous pingers on the submarine, synchronizing them with a built-in high precision clock, and sending response signals.

The monitoring of the submarine from the mother ship is carried out in the following way:

With the SSBL method, the dial tone from the synchronous pingers is received directly by the mother ship, and the position of the submarine is calculated. With the LBL method, the dial tone from the synchronous pingers is received by the mother ship via seabed transponders and, by using the slant range between the submarine and the transponder obtained by subtracting the distance between the mother ship and the transponder as measured separately, the monitoring calculations are conducted. In order to make this operation possible, two-cycle transponders have been adapted so that the transponders can respond to both the mother ship and the submarine using different frequencies. This has greatly increased the kind of frequencies used by this system. Also, with the acoustic frequency having been lowered to improve the S/N ratio, it has become difficult to secure wide bands, resulting in their being crammed into a narrow zone.

As is shown in the frequency distribution of Figure 3, the difference in adjacent signal frequencies is merely 100 Hz. A reception supervision device on the mother ship is used to separate them. This monitors the spectrum levels of all bands used, compares adjacent channel levels and determines the stronger to be the correct receiving channel.

2.2.4 Measuring the Base Line and Depth with Calibration

With the LBL method, calibration to determine the coordinates of the seabed transponders in advance is necessary. With this device, in order to shorten the calibration time, a direct calibration method was developed. By means of this method, the distance between the three transponders (base lines) and the respective depths can be measured directly. The transponders are equipped with high-precision hydraulic pressure sensors, and depth data are sent to the mother ship by measurement commands from the mother ship.

2.3 Device Structure and Function

The acoustic navigation system is comprised of the cable transmitter and the receiving array attached to the bottom of the mother ship, the input-output processing unit, the data processing unit and the X-Y plotter onboard the ship, the synchronous pinger on the submarine, and seabed transponders, etc., while the integrated control display device consists of the information processing unit, the control desk and the remote display unit, etc.

The interrogator signals from the mother ship cable transmitter are returned by the transponders and are received by the mother ship once more, enabling the position of the mother ship in relation to the sea bottom to be measured. Accordingly, interrogator signals are sent from the synchronous pinger of the submarine and are received by the mother ship either directly or via transponders, enabling the position of the submarine to be measured. Using these data, the positions of the mother ship and submarine are measured and recorded on the X-Y plotter as the wake.

With the integrated control device, in addition to numerically displaying various data such as the time and positions of the mother ship and the submarine on the

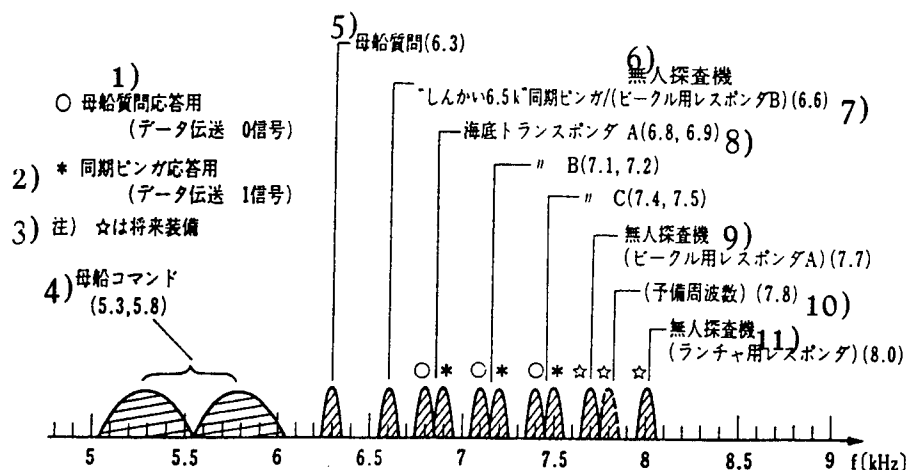


Figure 3. Frequency Distribution

Key:—1. For mother ship's queries and responses (data transmission: 0 signal)—2. For synchronous pinger responses (data transmission: 1 signal)—3. Note * denotes future loadings—4. Mother ship command (5.3, 5.8)—5. Mother ship query (6.3)—6. Unmanned investigation device—7. Shinkai 6.5K synchronous pinger (responder B for vehicle) (6.6)—8. Seabed transponder A (6.8, 6.9)—9. Unmanned investigation device (responder A for vehicle) (7.7)—10. (Spare frequency) (7.8)—11. Unmanned investigation device (responder for launcher) (8.0)

control desk, necessary information is displayed on the CRT. The exterior of this device is shown in Photo 1 [not reproduced].

2.4 Major Items

The major items of the acoustic navigation device and the integrated control display device are shown in Table 1.

Table 1. Major Items of Acoustic Navigation Equipment

Monitoring system	SSBL, LBL
Transmitting sound pressure	90 dB or more
Monitoring objects	up to 8 targets
Communications frequency	6.6 to 8.0 kHz
Monitoring range	up to 11,000 meters
Monitoring accuracy	LBL standard deviation: 30 m or less; SSBL 2.5% (100% or less of depth); 1.8% (60% or less of depth)
Monitoring output	X-Y plotter and CRT
X-Y plotter	AO version

2.5 Software

The application programs used in this device are outlined below.

(1) Sonic speed processing

With information from the SBT and STD units, the sonic speed at each depth is calculated. When doing so, the layer sonic speed adjustment method, which uses the

average sonic speed between the submarine and transponders by dividing it into several layers in the depth direction and obtaining the sonic speed of each layer beforehand, has been adopted. Also, sonic speed processing has the capability of graphically displaying how the sounds from the mother ship and submarine travel through the sea.

(2) Calibration

This device is equipped with the following three software items to aid in calibration:

—(i) Direct calibration: This method determines the position of the transponders from the information on the base line and transponder depths mentioned above.

—(ii) SSBL calibration: This method obtains the transponder positions by calculating averages after obtaining the position of each transponder by means of SSBL monitoring, making one of the transponders the reference and calculating the relative positions of the other transponders.

—(iii) LBL calibration: This method obtains the minimum square by the repetition method, with the slant range as the measuring data and the mother ship position and transponder positions as unknowns.

(3) Real-time tracking

The positions of the mother ship and submarine are calculated in real time. Monitoring methods for both the mother ship and the submarine include the SSBL and LBL modes, and the results are output on the X-Y

plotter, line printer, floppy disk, integrated control display device, multiple narrow beam acoustic depth measurement device, general-purpose computer system and an underwater voice unit. With the integrated control display device, the wake is displayed on the graphic display.

(4) Off-line tracking (reproducing monitored results)

The monitored results recorded on the floppy disk are reproduced, and are output on the X-Y plotter, line printer and graphic display. Not only the contents recorded by the acoustic navigation device, but also the results of monitoring by the acoustic navigation device of the diving vessel itself can be reproduced.

(5) Off-line tracking (adjusting and reproducing monitored results)

In seas where the submarine is navigating for the first time, since data on saline concentration and water temperatures used to determine the sonic speed cannot be obtained beforehand, the sonic speed is calculated by means of various estimates and monitoring methods. After the submarine surfaces, the exact sonic speed of the operating sea area is calculated using the saline concentration and water temperature data recorded on the STD unit of the submarine when navigating underwater. From these results, all monitored data recorded on the acoustic navigation device and the acoustic monitoring device of the submarine are adjusted, and the monitoring calculations are repeated. As a result, it becomes possible to record and display the wake more accurately.

(6) Collision prevention supervision processing when submarine surfaces

When the submarine surfaces, in order to avoid collision with ships sailing in the area, the integrated control display device collects information on other ships with the collision prevention support unit, and displays it together with the movement of the submarine on the graphic display.

2.6 Examples of Actual Data of Acoustic Navigation Device

Results of the calibration obtained from formal trial runs are shown in Figure 4. No significant differences were found in the results of the various calibrations, and with the results of direct calibration coinciding well with the results of LBL calibration, the usefulness of direct calibration has been verified.

Figure 5 shows the results of measuring the position of the mother ship with the acoustic navigation device. In Figure 5, the areas where dispersion can be observed (around 09:40 and 10:30) indicate SSBL monitoring, while extremely stable monitoring was obtained in the LBL monitoring areas.

3. Acoustic Monitoring Device

3.1 Device Outline

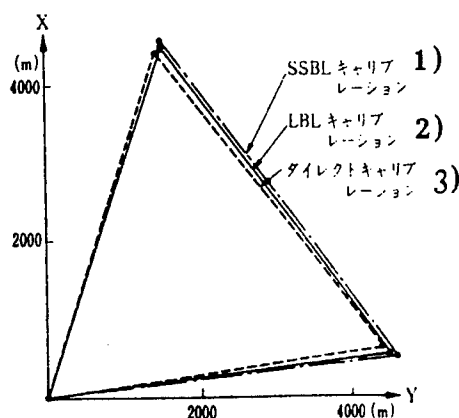


Figure 4. Base Line Measurement Data Per Calibration
Key:—1. SSBL calibration—2. LBL calibration—3. Direct calibration

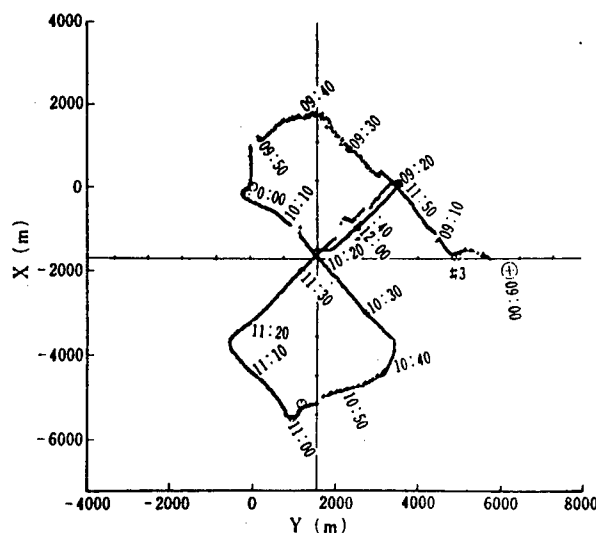


Figure 5. Mother Ship Monitored Data

The acoustic monitoring device is a subsystem, loaded on the submarine, that monitors its own position with the LBL method.

With the Shinkai 2000, the position of the submarine, as measured on the mother ship, was transmitted to the submarine by underwater voice units, but as the distance from the submarine increased, it ultimately took several seconds before the submarine could receive information regarding its own position. Therefore, with the Shinkai 6500, it was necessary to load a system that would enable the submarine to monitor its own position.

The following two problems were encountered when developing this device:

(1) Making it small enough to be loaded on the submarine.

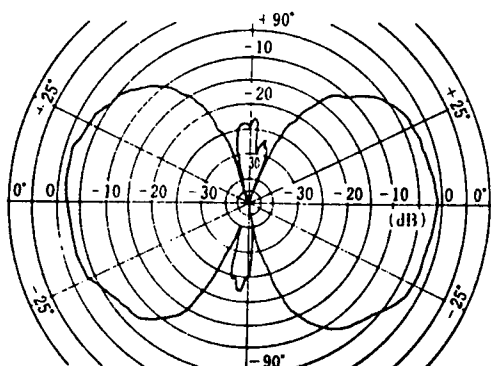


Figure 6. Directivity of Receiving Unit of Acoustic Monitoring Equipment

(2) Achieving monitoring distances of 5,000 meters.

In order to respond to the above requirements, the following countermeasures were taken:

(1) Minimizing its size: By replacing parts which had formerly been processed by hardware with software using microcomputers and lowering power consumption, the power source and other parts were made smaller.

(2) Improving noise tolerance: When loading the monitoring device on the submarine, the effect of the acoustic noise caused by the submarine was an object of considerable concern. As a countermeasure, by using array-type receiving units where compressed electrons were arranged vertically, the effects of acoustic noise from the screw and power source direction on the directivity of the receiving unit were decreased.

This receiving unit demonstrates the directivity shown in Figure 6, and has attenuation properties of 20 dB in the downward direction. The acoustic noise source from below attenuates significantly, and the horizontal response signals of the transponders are received normally.

3.2 Monitoring Method

The acoustic monitoring device employs the LBL method to monitor the submarine. Sonic waves are sent from synchronous pingers loaded on the submarine, signals returned to the submarine via the transponders are received, the propagation delay time is measured and, after being transferred to the slant range, these are used to obtain the position of the submarine.

3.3 Structure and Function

The acoustic monitoring device consists of the receiving unit loaded on the upper part of the submarine, and the main receiver and remote display unit loaded inside the

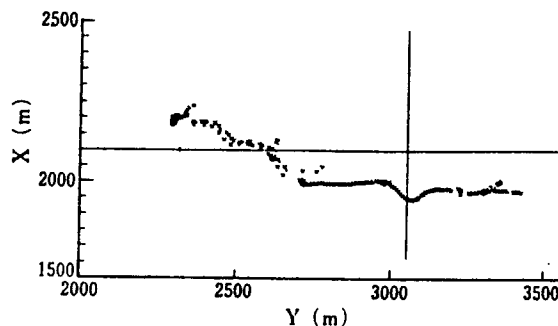


Figure 7. Monitoring Data by Submarine

pressure-proof shell. Synchronous pingers which generate interrogator signals, the synchronous control section which generates transmitting synchronizing signals and seabed transponders are shared with the acoustic navigation device. The exterior of the acoustic monitoring device is shown in Photo 2 [not reproduced].

3.4 Major Specifications

The major specifications of the acoustic monitoring device are shown in Table 2.

Table 2. Major Specifications of Acoustic Monitoring Equipment

Monitoring system	LBL
Objects monitored	Up to 3 targets
Monitoring range	Horizontal distance: up to 5,000 meters
Maximum monitoring rate	4 seconds

3.5 Experimental Results

The monitoring results of the submarine with the acoustic monitoring device are shown in Figure 7. These results and the data on the position of the submarine as measured on the mother ship corresponded well.

4. Observation Sonar

4.1 Device Outline

In order for the submarine to move in deep waters and fulfill its mission safely, it must be able to detect, identify, evade and induce obstacles ahead. For this purpose, television cameras and observation sonar have been loaded on the Shinkai 6500. Since television cameras can only survey several meters in deep water, even when using optical illumination, observation sonar are required for long-distance surveillance.

The observation sonar device images objects in the water using ultrasonic waves, and can detect objects 110 meters away in the high resolution mode of 300 kHz and 300 meters away in the long-distance detection mode of 100 kHz.

Similar to the ultrasonic imaging device being developed by Oki Electric^{6,7}, the basic imaging principle of the observation sonar employs the cross fan beam scanning method with the cross linear array and, with this device, in order to widen the view angle, the capability of mechanically rotating the transmitting and receiving units horizontally has been added, with this capability being extended so that horizontal sectional images of plus/minus 90° can be displayed. It is also equipped with a long-distance detection mode employing one beam mechanical scanning that transmits and receives using one channel each of the transmitting and receiving units.

In this section, the problems encountered in developing the observation sonar and the imaging method and their countermeasures will be explained, and the imaging mode, structure and characteristics of the device will be described. Finally, examples of the images will be shown.

4.2 Developmental Problems and Countermeasures

The biggest problem encountered in realizing the observation sonar was the hydraulic pressure tolerance of the transmitting and receiving units. This problem was solved by using the acoustic mismatching backing method, and satisfactory results were obtained.⁸

When the transmitting and receiving units are operated, sounds hit not only the front of the element, but also its back. The sonic waves sent behind bounce back from a chassis, etc., and come to the front, interfering with the sounds sent to the front, and deteriorate the element's directivity. Therefore, as an example, acoustic absorbents, such as cork rubber, have been affixed to the back of the element to absorb the sounds sent behind. However, material such as cork rubber will collapse at water depths of 6,500 meters, and will not be useful as acoustic absorbents. Therefore, with the observation sonar, the acoustic mismatching backing method has been adopted. With this method, as shown in Figure 8, the backside of the piezo electrons are covered with an acoustic mismatching layer, consisting of a rubber layer and a metal layer, and ultrasonic waves are prevented from being sent behind the array. The acoustic mismatching layer is not mechanically soft, and is capable of supporting the piezo electrons under high pressure. Also, the piezo electron array attached to the acoustic mismatching layer is stored in a rubber boot filled with oil with high acoustic permeability, and is structured to balance the pressure against the external pressure.

The transducer model's transmitting and receiving sensitivity under various hydraulic pressures was measured in a hydraulic pressure tank by the mutual calibration method. As shown in Figure 9, at 680 kgf/cm² the transmitting and receiving sensitivity declines only 1-2 dB from that seen when the hydraulic pressure is 10 kgf/cm², and since the reproducibility also proves to be high when the hydraulic pressure is changed, the effectiveness of this method has been verified.

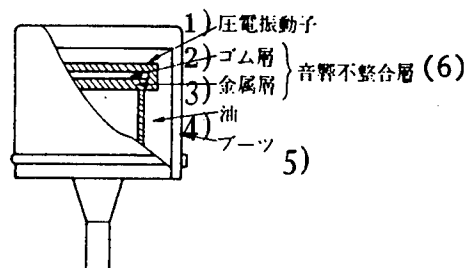


Figure 8. Basic Structure of Test-Manufactured Receiving Unit

Key:—1. Piezo oscillator—2. Rubber layer—3. Metallic layer—4. Oil—5. Boot—6. Acoustic mismatching layer

4.3 Imaging Methods

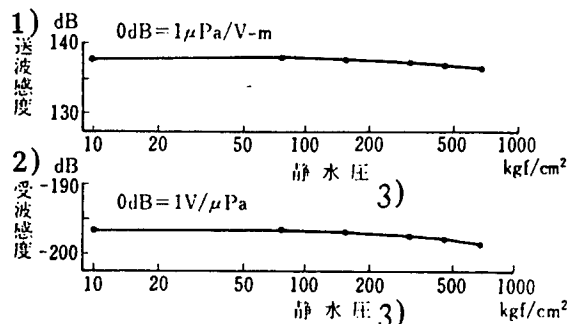


Figure 9. Sensitivity Pressure

Key:—1. Transmitting sensitivity—2. Receiving sensitivity—3. Hydraulic pressure

Cross Fan Beam Scanning Method

With the observation sonar, the cross fan beam scanning method is used as the image reproduction method. As shown in Figure 10, this method uses a cross linear array, which crosses the vertically-arrayed transmitting linear array with the horizontally-arrayed receiving linear array, and horizontally-spread thin fan beams are generated from the transmitting unit array, while vertically-spread thin fan beams (expecting beams) are generated from the receiving unit array. The integrated beam pattern is given by multiplying the transmitting and receiving beams, and becomes a pencil beam in the direction where the two overlap. By controlling the phase difference to each element of the transmitting and receiving arrays, transmitting beams and receiving beams can be scanned independently in the vertical and horizontal directions, respectively, while the pencil beam can be oriented in any direction. In addition, by using a short pulse for transmitting signals, the resolution of the distance direction by propagation delay time differences becomes possible, and object surfaces can be scanned three-dimensionally.

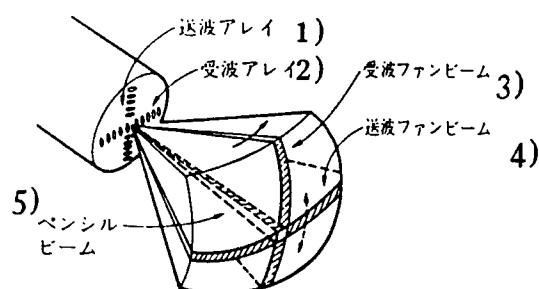


Figure 10. Principle Diagram of the Cross Fan Beam
Key:—1. Transmitting array—2. Receiving array—3. Receiving fan beam—4. Transmitting fan beam—5. Pencil beam

4.4 Imaging Modes

Using this three-dimensional resolution function, the observation sonar is capable of four kinds of sectional display: the C mode (front image), B mode (horizontal section) and its partial magnifying mode (BZ mode), and the BV mode (vertical section), and it is possible to grasp the three-dimensional shape of objects.

The horizontal section mode has been extended to display the plus/minus 90° range by interlocking with mechanical scanning. Images are formed by the mechanical scanning rotation and are stored on the picture, but with regard to the plus/minus 20° direction in front of the device, it is renewed three times each second by means of electron scans. The long-distance detection mode uses one channel each of the transmitting and receiving units and, similar to radar, forms horizontal sectional images with one-beam mechanical scanning.

4.5 Structure and Function

The observation sonar consists of four parts: the transmitting and receiving unit set up inside the sonar dome on the uppermost tip of the submarine, and the operation section, the power supply section and the display section mounted inside the pressure-proof shell.

The transmitting and receiving unit (Photo 3 [not reproduced]) has built-in transmitting and receiving unit arrays inside the black rubber boot in the front section and electric circuits, such as transmitting and receiving amplifiers, inside the titanium pressure-proof container in the back section. Ultrasonic pulses are transmitted and received according to the parameters (transmitting and receiving level, pulse width, etc.) sent from the operation section (Photo 4 [not reproduced]), and are sent to the operation section after the transmitting signals have been digitized. The operation section has three functions—indicating the image mode and focal distance, controlling the operation of the entire system, and signal processing which, after performing image reproduction by beam forming and scanning conversion, converts receiving signals into video signals for output.

The power supply section (Photo 5 [not reproduced]) has a built-in direct current stabilization power source which, in addition to supplying the operation section with a power source, displays the ultrasonic image on the CRT monitor in parallel with the display section (Photo 6 [not reproduced]).

4.6 Major Device Specifications

The major specifications of the observation sonar are shown in Table 3.

Table 3. Major Specifications of Observation Sonar

Item/Mode	C Mode	B.BZ Mode	BV Mode	PPI Mode
1. Frequency	approx. 300 kHz	approx. 300 kHz	approx. 300 kHz	approx. 100 kHz
2. Detection range	110 m	110 m	110 m	300 m
3a. View angle (H)	approx. $\pm 20^\circ$	approx. $\pm 20^\circ$	approx. $\pm 20^\circ$	approx. $\pm 90^\circ$
3b. View angle (L)	approx. $\pm 15^\circ$	approx. $\pm 15^\circ$	approx. $\pm 15^\circ$	(Depends on mechanical scanning)
4a. Resolution (H)	approx. 1.3°	approx. 1.3°	approx. 1.3°	approx. 10°
4b. Resolution (L)	approx. 1.3°	approx. 1.3°	approx. 1.3°	approx. 25°
5. Frame rate	0.4 F/S	3 F/S	0.4 F/S	

4.7 Imaging Examples

Imaging examples of the observation sonar are shown in Photos 7-10 [not reproduced]. Cylindrical shoots, 12 meters in diameter, float 40 to 60 meters in front of the transmitting and receiving unit. Photo 7 [not reproduced] is an example of the C mode, Photo 8 [not reproduced] the B mode and Photo 9 [not reproduced] the BZ mode. Photo 10 [not reproduced] is an example of the BV mode at the breakwater.

5. Conclusion

An acoustic navigation device, integrated control display device, acoustic monitoring device, observation sonar and the supporting software for loading the system on the Shinkai 6500 have been developed. The underwater investigation vessel Shinkai 6500, which is supported by various items of equipment including the above, established the current world depth record for submarine vessels of 6,527 meters during the formal trial run in the Japan Trough off Sanriku on 11 August 1989, and the various equipment items we developed have also been proven to be effective. The Shinkai 6500 is scheduled to be operated by the Oceanic Science and Technology Center, and various investigation activities using it are expected to contribute greatly to the world's deep sea development.

The basic design of this system was handled by the Equipment Measuring Systems Research Department,

Integrated Systems Research Institute, while as for the final design, the acoustic navigation device, acoustic monitoring device and observation sonar were handled by the Equipment Measuring Operation Division Technology Department No 2, Mounting Technology Department, the integrated control display device by the Complex Systems Operation Division Technology Department No 1, Mounting Technology Department, and the software by the Equipment Measuring Operation Division Technology Department No 3.

Finally, we would like to express our deepest gratitude to those at the Oceanic Science and Technology Center, Kawasaki Heavy Industries Co., Ltd., Kobe Shipyard, and Mitsubishi Heavy Industries for their direction and cooperation in this development.

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- (Source: OKI ELECTRIC RESEARCH AND DEVELOPMENT Issue No 146, Vol 57 No 2)

EC Sponsors German Mitsubishi Plant

91AN0261X Amsterdam *COMPUTERWORLD*
in Dutch 30 Jan 91 p 22

[Excerpts] Paris (IDG)—For the first time in history, the European Community is to invest in a Japanese company. Aid amounting to 5.8 million European currency units (approximately 13 million Dutch guilders) will be granted to Mitsubishi for the construction of a components plant in Germany. The plant will start the production of 4-Mbit dynamic random-access memory chips (DRAMs) in 1992.

Recently, the EC seriously criticized Mitsubishi for dumping its semiconductors in Europe. This was happening at a time when the Joint European Submicron Silicon Initiative (JESSI) was in trouble. Philips' decision to withdraw from the program has put its partners, Siemens and the French SGS-Thomson, in a difficult position. [passage omitted]

With regard to the subsidies for the Mitsubishi plant, the EC proposes that the subsidy rules that apply to American firms should be extended to Japanese companies. Seventy percent of all semiconductors in Europe are imported from Japan. The decision provoked heavy reactions within European industry, but the Community sees no reasons for not giving subsidies. Every company with research facilities in Europe is entitled to subsidies, providing it complies with certain regulations. Subsidies

had previously been granted to Motorola, which started up a factory in Ireland, and to an Italian subsidiary of Texas Instruments.

Mitsubishi Trial-Manufactures World's First High-Speed Dynamic Optical Neurochip

91P60247A Beijing *ZHONGGUO KEXUE BAO*
[CHINESE SCIENCE NEWS] in Chinese 2 Jul 91 p 3

[Article by Zhang Siming [1728 1835 2494]: "Dynamic Optical Neurochip Developed"]

[Summary] Mitsubishi Electric Corporation recently trial-manufactured the world's first high-speed dynamic optical neurochip. The new chip has a learning speed of 600 MCUPS (million synaptic connection updates per second)—2,000 times that of a conventional neurochip and the highest value reached to date worldwide. Its trial manufacture represents an important new step toward final development of an optical neurocomputer.

According to Mitsubishi, the new chip has eight neural elements on a 6mm x 6 mm x 6mm cubic chip. On the chip are integrated an array of eight GaAs LEDs and an array of 8 x 8 [=64] optical detectors with controllable sensitivity (i.e., with changeable optical-electric conversion efficiency). Mitsubishi points out that, while the new chip has only eight sensing elements, interconnection of several such optical neurochips would permit development of an optical neurocomputer with several hundred or even several thousand neural elements.

Laser Separation of Fuel-Grade Uranium

91P60248A Beijing *SCIENCE AND TECHNOLOGY*
DAILY in Chinese 6 Jul 91 p 3

[Unattributed article]

[Summary]The Japan Atomic Energy Research Institute has used a laser to produce enriched U-235 from natural uranium. The process increased the 0.71% content of natural uranium ore to 5%, producing 0.01 grams of uranium an hour. According to the Institute's estimates, laser technology is capable of separating out 65% of U-235, proving that laser enrichment technology will ultimately become a viable commercial technique.

**Ministry of Posts and Telecommunications FY91
Policy Outline**

*91FE0663A Tokyo JAPANESE GOVERNMENT
REPORT in Japanese Aug 90 pp 1-21*

[Text] FY1991 Information and Communications
Policy Outline: Preparing a Foundation for the Use of
Information in Daily Life (Ministry of Posts and Tele-
communications, August 1990)

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Foreword. Japan's Status and Tasks

**1. Preparing a Foundation for the Use of Information in
Daily Life**

—A. Achieving a lifestyle with a real sense of abundance:
Japan has developed into one of the world's economic
superpowers. That has created some degree of leisure
in the life of each Japanese, and made it possible for
each to enjoy an abundant consumer lifestyle. On the
other hand, the level of social capital that supports our
lifestyle certainly cannot be considered adequate when
compared with long-standing infrastructures of
Europe and the United States.

To make it possible to deliver a lifestyle that will give a
real sense of abundance to individual Japanese, it will be
necessary to build up social capital that is directly linked
to improving the quality of life, in accordance with the
needs of the people.

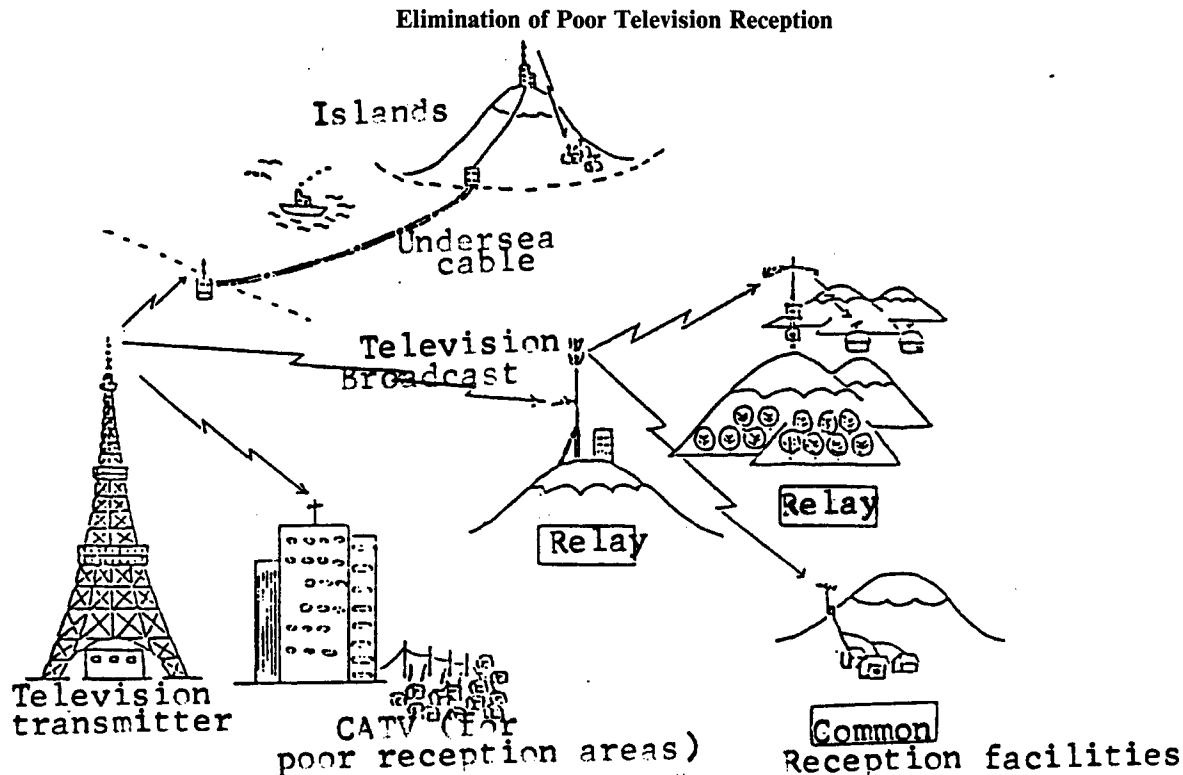
—B. Preparing a foundation for use of information in
daily life: Now that [electronic] information has come
to play an important role, information and communi-
cations have become things we cannot live without. At
present, however, it cannot be said that we have gone
far enough in preparing a foundation for the use of
information in daily life such that it is closely related
to the life people live. For example, television has
already become a necessity of daily life, but there are
many areas, primarily in the remote countryside,
where television reception is not good. There are also
more and more places in the cities where picture
quality has deteriorated because of multi-story build-
ings. Thus, the delay in preparing a foundation for the
use of information in daily life has become an obstruc-
tion in terms of realizing an abundant lifestyle.

Preparation of a foundation for information and com-
munication is being done, at present, primarily at the
initiative of the private sector. However, in order to
prepare a foundation for the use of information in daily
life as part of the process of forming a highly informa-
tion-oriented society, it will be necessary to make an
appropriate division of responsibilities between the gov-
ernmental and private sectors in fields where it is diffi-
cult to assure profitability, and to carry out such prepa-
rations in a balanced manner. Because there has been a
marked delay in what should be the government's part of
the foundation for the use of information in daily life, we
want to actively promote preparation of that foundation.

**2. Encouraging Caring Administration of Posts and
Telecommunications**

—A. Administration from the people's perspective: As
the strength of the way of life of the citizenry shifts
from physical abundance to a more relaxed lifestyle,
the people are beginning to demand a way of life that
expresses their individuality, while continuing to bless
them with physical prosperity. Moreover, Japanese
society is changing to one marked by mutual recogni-
tion of the existence of diversified sets of values.

With the diversification of lifestyles, demands for prod-
ucts and services have also diversified. At the same time,
the capability for more flexible and multi-faceted
responses has been sought within the administrative



functions which should form the foundation for the way of life of the citizenry. For that reason, it is necessary to improve administrative functions from the viewpoint of the lifestyle of the people, such that it can understand the trend of popular demand for administrative services and implement appropriate measures in response to that demand.

—B. Caring administration of posts and telecommunications: In today's highly mechanized civilization and information-oriented society, it is necessary to give due importance to "person-to-person contact," and to work out measures in which "human warmth" can truly be felt. Accordingly, MPT is promoting "caring administration of posts and telecommunications" in order to actively develop measures for the well-being of the people from that perspective.

In the field of information and communications, where there has been a remarkable technological revolution, it will be necessary to promote measures to find applications of new technology on the user's side, not just as conceived on the supplier's side, in order to truly serve the advancement of the welfare of the citizenry. That is, it is necessary to consider how each citizen can carry out the communications he himself desires. We want to go forward with a caring administration of posts and telecommunications to bring about a relaxed and attractive way of life, by putting effort into creation and use of communication networks to link person to person, and

by seeking the enhancement of information and communication services such that everyone can take part in community activities.

I. Achieving a Lifestyle with a Real Sense of Abundance

We will correct gaps in the life information environment, and bring about a lifestyle among the people in which there is an equal sense of abundance.

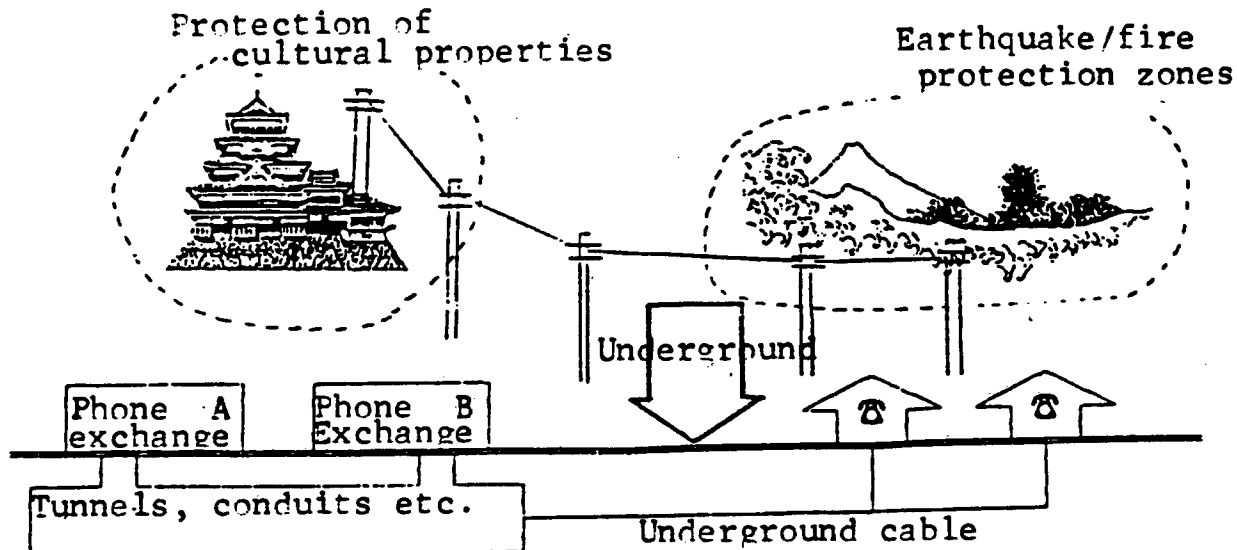
(1) Projects to prepare a foundation for the use of information in daily life: To bring about a lifestyle among the people in which there is an equal sense of abundance, it is important to actively promote preparation of a foundation for the use of information in daily life that is closely related to the life of the people.

For that reason, we will first encourage construction of a mobile communications infrastructure, including towers for base stations, so that car phones and pocket pagers can be used anywhere in Japan.

Television has already become indispensable in daily life. So that all Japanese can enjoy it, we will also encourage preparation of facilities to eliminate conditions that hinder good reception in remote areas and in big cities.

We also want to improve the security and reliability of telecommunications. We will encourage the use of underground cables for telecommunications in order to be ready for a highly information-oriented society, and

Moving Telecommunication Cables Underground



to encourage town renewal, facilitate fire-fighting, rescue and snow removal operations, and improve scenic views.

Moreover, to improve the lifestyle of people in remote areas to which electronic information use has not extended, we will encourage the preparation of remote communication centers to correct the information and lifestyle gaps between such areas and the cities.

It has also been pointed out that destruction of the ozone layer by such things as fluoro hydrocarbons has an impact on physical health (increased incidence of skin cancer etc.) and crop yields. Therefore, we will stop using substances which will destroy the ozone layer, develop technology for the direct protection of the ozone layer, and encourage the use of that technology in building environmentally sound facilities for use of the electromagnetic spectrum.

We are also studying the promotion of such things as a project to build facilities to monitor the electromagnetic spectrum and a project to provide high-definition television. We want to bring about an abundant way of life within a highly information-oriented society.

(2) Reduction of rates and diversification of services: Five years have passed since the telecommunications system reform of 1985. In that time there has been a steady decline in rates for various services. In the future, as the highly information-oriented society of the 21st century becomes a reality, it will be necessary to further improve the quality of services, further encourage reduction of rates and diversification of services, and promote benefits to the people and users to the maximum extent.

On the basis of earlier government measures on the nature of NTT, and from the perspective of encouraging fair and effective competition and improving the operation of NTT, we will steadily promote such measures as

introducing and thoroughly implementing a system with an NTT long-distance group and separate regional operating groups, separating mobile communications operations, assuring network openness so that other operators can use the NTT network on the same footing as NTT itself, implementing NTT's medium and long distance digitization project as soon as possible, and encouraging the streamlining of NTT operations.

We are devising measures for the necessary support of telecommunication operators, who play a central role in the highly information-oriented society, such as insuring the facilities investments of new operators in the process of network formation

II. Forming Vital Regional Communities

We will help build hometowns filled with individuality.

(1) Expanding regional availability of personnel and software in communication and broadcasting fields: At present, the biggest tasks in promoting the use of information in outlying areas are the training of nuclear personnel (the telecommunications staff) and the supply of appealing outgoing information (media/software). To improve this bottleneck to the use of information in outlying areas, it will be necessary to encourage mutual exchanges and link-ups among a broad range of regional communication and broadcasting projects (telecommunication projects), as well as effective, mutual use of their management resources (human and technological capital). It is also necessary to deploy personnel training functions and information software production functions, accumulated by the big cities and existing operators, into the outlying regions and to form bases in those regions.

To that end, we will set up regional telecommunication liaison centers in each region of Japan, and will engage in programs to encourage liaison, including education of telecommunications staffs, joint preparation of media and software, and mutual exchanges. We will also encourage a clear-cut switchover from information originating in Tokyo to that originating in outlying regions, and contribute to realization, in each region, of a prefecture that concentrates on regional information and culture.

(2) Regional development using electromagnetic media: It is easy to install facilities for information and communication systems that use the electromagnetic spectrum, and it is simple to use such systems. They are consequently expected to assist in the revitalization of regional society.

For that reason, we are going forward with a program to select a model district in each region, dig out the needs for spectrum use in accordance with the actual situation of the individual district, and design a system image suited to those needs. A skiing information guide system, intended to improve and diversify the use of ski resorts, is being considered in the Hokkaido and Shinetsu regions. Farm village information systems are being considered in the Kanto and Kyushu regions to increase agricultural productivity and revitalize farm villages. The Hokuriku and Shikoku regions have studied tourism information systems to increase convenience for tourists and revitalize tourist sites; the regions have requested that such systems be brought to a practical level.

We plan to devise a variety of assistance measures, and thus bring these projects to fruition, revitalize communities in these districts, and improve the lifestyle of their residents.

(3) Upgrading and diversifying the Post Office network: Post offices form a nation-wide network with about 24,000 locations from mountain to beach to island throughout Japan. In order to use this network to the utmost and to contribute further to the convenience of outlying residents and the promotion of local communities, it will be necessary to upgrade and diversify the post office network to make each post office an information and communications base for the local community.

To that end, we will deploy New Media equipment to post offices, and build a satellite communications network capable of exchanging video images among localities. We will also build mobile radio communications networks within local districts.

After completion of the capitol area postal network centered on the new Tokyo Post Office that opened on 6 August 1990, a new, large-scale post office will be built in Osaka as the center of a Kinki area network.

We will also establish specialized delivery post offices in large cities and their suburbs, and strive to strengthen postal networks in large cities.

Even though they are in the centers of cities and towns, most post offices are still in relatively low buildings. Consistent with the efficient use of space in public spaces, we will promote better use of post office land through joint construction of post offices and private office buildings, and thus contribute to local development.

In order to respond to strong demands from local residents, we will diversify window services, so that such things as residence cards and passports can be issued at post office windows.

III. Enhancement of the Industrial Economy

We will contribute to abundant management and the creation of business opportunities.

(1) Building next-generation communication networks: Networks have been undergoing digitization and adaptation to ISDN so that data and graphics, as well as voice, can be sent quickly and accurately. But in their present state, it is all networks can do to send still pictures; they are unable to handle animation or high-speed data communications. It is also difficult to use advanced services to eliminate the sense of inconvenience when the receiving party is already on the line or absent.

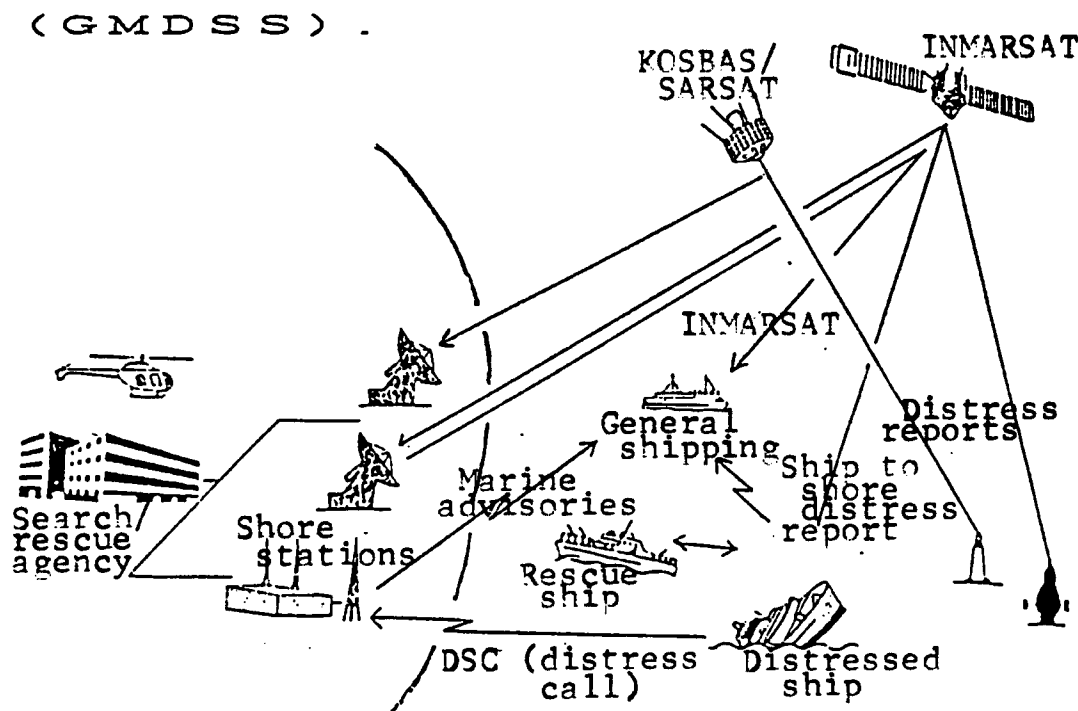
To resolve such problems, it will be necessary to replace existing switches, transmission equipment and transmission routes, and to greatly upgrade network processing capabilities. It will also be necessary to provide for intelligent processing and multi-media processing, and to enable communications "at any time, from any place, by any means."

We are striving to support this sort of next-generation network for the 21st century, and to bring about an abundant and relaxed society through communications.

(2) Upgrading industrial networks: With the expansion of information needs in the field of industry, there have been demands for advanced information and communication services, primarily graphics and data. The VSAT system is an information and communications system that uses satellites and provides a variety of functions at low cost. That system makes it possible to build efficient, advanced industrial networks with superior resistance to natural disasters. By promoting the development of model systems suited to various industrial fields and the reduction of equipment costs, we are assisting the creation of new industrial networks. The financial sector (banks and security firms which have particularly heavy information needs) and the distribution sector (transportation and retailing) have taken the lead in introduction of the VSAT system.

The new Global Marine Disaster Safety System (GMDSS) advocated by the International Maritime Organization (IMO) is to be introduced worldwide beginning in 1992. GMDSS will greatly advance the automation, simplification and reliability of disaster

GMDSS



communications by introducing such things as satellite communications and digital communication technology. Japan is preparing the ordinances necessary for its introduction, and is devising support measures to encourage its introduction.

(3) Encouraging development of communications software: ISDN, which is the 21st century trunk communications network to replace the telephone network, is markedly superior to conventional telephone nets in terms of transmission capacity and switching capabilities. The services supplied through ISDN are expected to serve a great role in business management and the lives of individuals.

To make ISDN easier to use, it will be necessary to promote standardization and assure inter-operability in such fields as personal computer communications, graphic communications, multi-media communications that can handle all media, and inter-LAN communications. In addition, we are promoting the development of terminals suited to user preferences, and of applications software that is convenient and easy to use.

IV. Contributing to the Formation of a New International Community

We will seek mutual understanding through communications, and contribute to formation of a new international society.

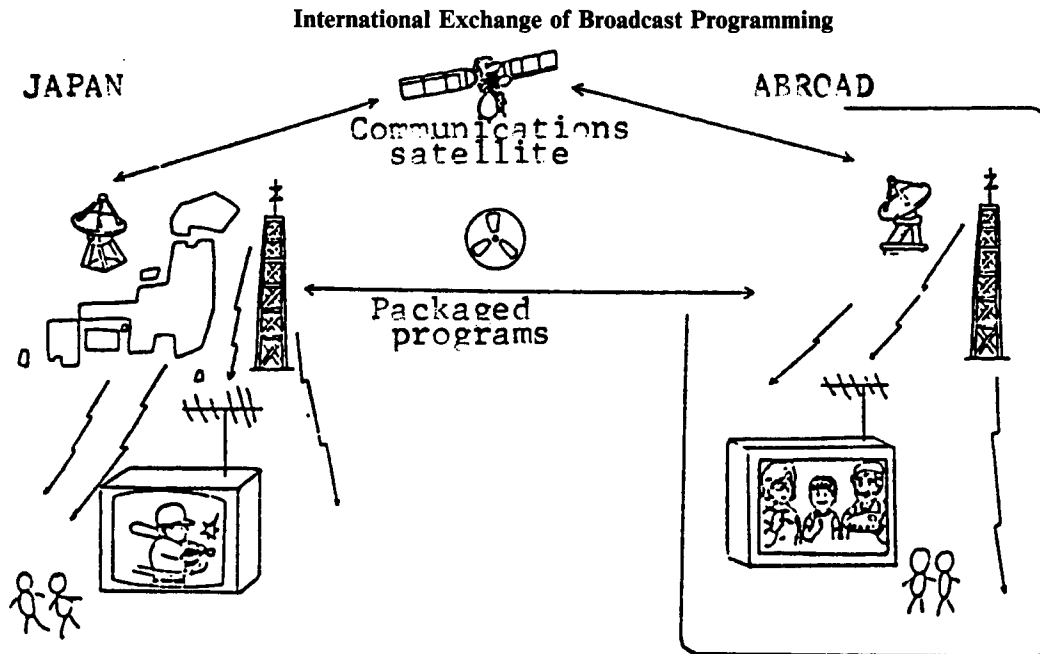
(1) Exchange of broadcast programming

In developing countries, broadcasting is expected to play a great role in nation building and in building human resources. However, there has been an expectation of cooperation from advanced countries in the area of broadcast programs; it is necessary that Japan's wealth of broadcast programming, especially educational programs, be used to enhance the broadcasts of developing countries.

As can be seen in the structural consultations between Japan and the United States and in the rise of the argument that "Japan is different," the issue of international friction includes cultural friction as well as economic friction. In such circumstances, deepening mutual understanding with other countries is an urgent task for Japan. It is particularly important that a proper image of our country be conveyed overseas through television broadcasting, which has a great social impact in all countries.

For that reason, we will prepare a framework to assist in the international exchange of broadcast programming and cooperate in the development of broadcasting in developing countries, and thus encourage mutual, international understanding.

On the other hand, international shortwave broadcasts are important as a means for Japanese overseas to obtain information, in addition to increasing international understanding. Therefore, we plan to further expand and enhance overseas relay broadcasting.



(2) Increased cooperation in development of human resources for developing countries: With the expansion of social and economic activity on a global scale, the role played by communications and broadcasting has been growing more and more important in recent years. In developing countries, however, there is inadequate know-how regarding how to use communications and broadcasting to stimulate social and economic activity. It has therefore become an urgent task to build up the human resource base in the field of communications and broadcasting. It is thought that the most effective way to handle that task would be for the youth who will bear the responsibility for the future, with their flexible mental capability, to learn the effective uses of communications and broadcasting, and recognize their importance.

For that reason, will invite in "communication juniors" who can be expected to make rapid progress in the communications and broadcasting field in developing countries, and expose them to the present situation in Japan. That will deepen their awareness of the important role communications and broadcasting will play in the development of social and economic activity.

(3) Rapid Expansion of International VAN Services: Japan had already implemented international VAN operations under bilateral consultations with the United States and with Britain, but a further development of international VAN operations can be expected as a result of the rapid expansion of the scope of services under the Japanese-U.S. agreement at the end of July, 1990.

Countries other than the United States and Britain have also expressed strong interest in starting up international VAN operations. Consequently, we will further expand

the area covered by international VAN services, particularly emphasizing Asia, with which we have close geographical and economic ties, and with the dynamic countries of Europe. We have attempted to firm up Japan's foundation as a point of origin for information that links Asia and Europe.

(4) International exchange of technology: Japan's technological capability has come to receive high praise internationally; this is another field in which we have been asked to contribute to the international community. We have also taken up the task of preparing an open research system in response to criticism that Japan is "eager to introduce technology from abroad but reluctant to make advanced technology available."

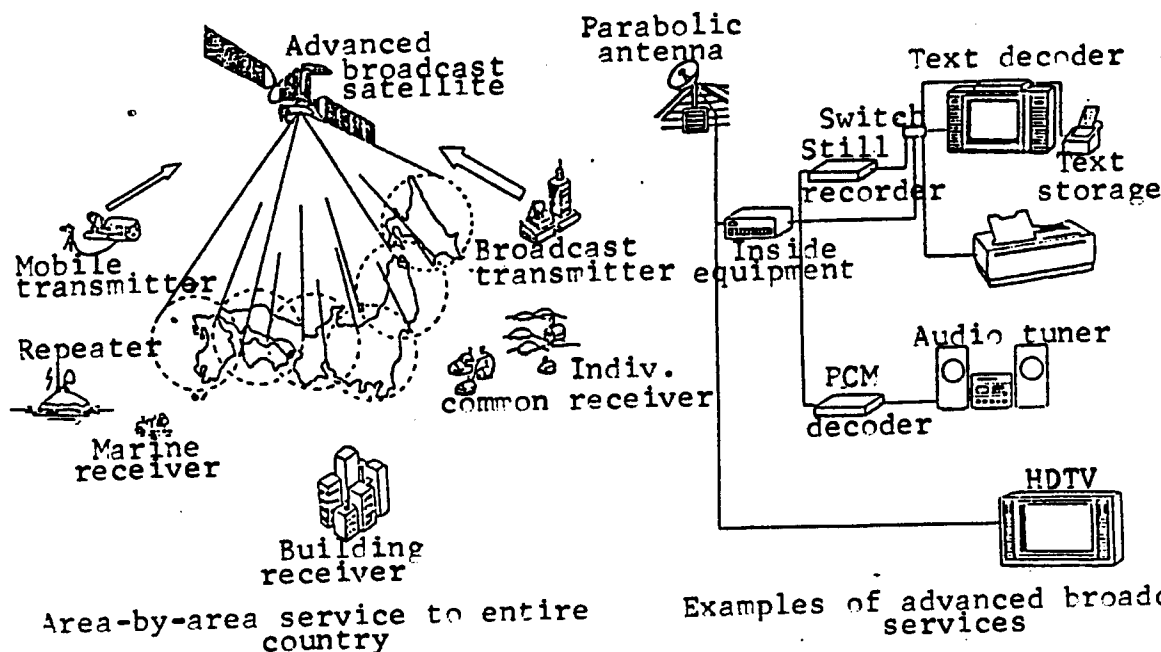
We will therefore build up international joint research by convening international research conferences and by inviting foreign researchers to Japan and sending Japanese researchers abroad. We will also promote international technical exchanges under bilateral science and technology agreements with the United States, Canada, West Germany and others.

V. Development of Technology to Build a Bright Future

We will open up the unknown potential of information and communications, and build an abundant 21st century.

(1) Communications and broadcast technology satellites: With the provision of private satellite communication services and the beginning of private satellite broadcasting scheduled for Broadcast Satellite No. 3 (BS-3) the use of communications and broadcast satellites is growing steadily. It has become necessary for the

Advanced Satellite Broadcast Services



national government to establish a foundation of autonomous satellite technology, and to continue development of technology for more advanced satellite communications and satellite broadcasting.

Accordingly, we will promote development of a communications and broadcast technology satellite with a goal of launching in 1996, and will promote the development of (1) advanced mobile satellite communications technology to conduct communications from any location using small, portable communications equipment, (2) advanced satellite broadcasting technology capable of wide-area, high-definition television broadcasting and integrated digital broadcasting (ISDB), and (3) intersatellite communications technology to efficiently conduct transmission of data from earth-monitoring satellites and communications with space stations.

(2) Increased R&D on telecommunication frontiers: To establish a base of technology to support the advanced information society of the 21st century, it will be necessary to carry out, from a broad perspective, basic and advanced R&D in the field of telecommunications.

To do that, we will engage in an international exchange of research based on cooperation among industry, academia and government. We will promote further R&D on six tasks in the three fields of high-speed communications technology, bioelectronic and intelligent communications technology, and advanced function network technology. We will also begin new R&D on physiological functions.

(3) Development of a new system for use of the spectrum: To implement a system capable communications "at any time, from any place, by any means," we will encourage development of digital car phones, "personal handyphones" that can be carried in the streets, and a new generation of microcell portable phones with a very large capacity for subscribers, thus bringing about the mobile telecommunications system of the future (FPLMTS).

We will also promote R&D on communications systems in the infrared and sub-millimeter wave bands, R&D on millimeter wave band systems for auto collision avoidance and position perception, and R&D on millimeter wave and optical band remote sensing systems for observation of earth's environment. Thus, we will use frequencies from the millimeter wave through optical frequency bands.

Moreover, to cope with demands for spectrum which are rapidly becoming very tight, we will encourage development of technology for intelligent use of the electromagnetic spectrum. This will allow effective use of the spectrum by such means as having individual radio stations change their zone structure and channel usage in accordance with the state of use of the electromagnetic spectrum.

Appendix: Measures in FY91

I. Achieving a Lifestyle with a Real Sense of Abundance

Budget items

I.A. Preparation of an information and communications foundation in response to changes in the living environment

I.A.1. Preparation of an information and communications foundation through public works investment

I.B. Encouraging the spread of next-generation broadcast methods

I.B.1. Encouraging the spread of high-definition television

I.B.2. Survey research on encouraging the spread of new broadcast methods through satellite broadcasts

I.C. Enhancement of broadcast services

I.C.1. Survey research on measures for basic planning for the popularization of broadcasting

I.C.2. Research on new broadcast methods

I.C.3. Promotion of measures for areas with poor television reception

I.C.4. Preparation of a foundation for CATV

I.D. Preparation of an environment for the use of information and communications for a carefree society

I.D.1. Survey research on national livelihood tasks in the fields of information and communications

I.D.2. Promotion of protection of the global environment

I.D.3. Preparation of an advanced emergency communications network

I.D.4. Survey research on electromagnetic environment safety standards and measures

Taxation

I.A. Assistance for enhancement of broadcasting services

I.A.1. Extension of taxes to strengthen the foundation of smaller businesses involved in CATV projects

I.A.2. Measures for non-application of enterprise tax for businesses involved in CATV projects

I.A.3. Tax assistance measures to promote high-definition television broadcasting

I.A.4. Tax assistance measures to promote community broadcasting

I.A.5. Extension of enterprise tax reduction measures for general broadcasters

I.B. Special depreciation for facilities (such as SHF stations) to overcome obstacles to urban television reception

Interest-free lending

Projects for preparation of local high-definition television systems

Fiscal investment and loans

I.A.1. Projects to prepare a foundation for upgraded broadcasting, such as projects for preparation of local high-definition television systems

I.A.2. Encouraging the spread of high-definition television satellite broadcasting services through the Telecommunication Satellite Corp. of Japan

II. Forming Vital Regional Communities

Budget items

II.A. Encouraging local information and communications projects

II.A.1. Implementation of local information and communications projects

II.B. Encouraging information use for local renewal

II.B.1. Survey research on how to encourage local information use

II.B.2. Survey research on use of the electromagnetic spectrum for local renewal

II.C. Encouraging projects to prepare special facilities using the vitality of the private sector

II.C.1. Urgent implementation of projects to prepare special facilities using the vitality of the private sector

Taxation

II.A.1. Tax assistance measures to encourage preparation of local Telecommunications Liaison Centers

II.A.2. Expansion of national livelihood tax system

II.A.3. Extension and expansion of multi-polar tax system

Interest-free lending

II.A.1. Projects in designated Teletopia locales, including local Videotex projects and local CATV projects

II.A.2. Projects to prepare national livelihood facilities, including telecommunications research parks and telecommunications plazas

II.A.3. Projects to prepare local Telecommunications Liaison Centers

II.A.4. Projects to prepare facilities for joint labor development and supply

II.A.5. Projects to prepare facilities for community broadcasting

Fiscal investment and loans

- II.A.1. Projects in designated Teletopia locales
- II.A.2. Projects to prepare national livelihood facilities
- II.A.3. Projects to prepare local Telecommunications Liaison Centers
- II.A.4. Projects to prepare facilities for community broadcasting
- III. Enhancement of the Industrial Economy

Budget items

- III.A. Encouraging upgrading of information and communications networks
 - III.A.1. Encouraging standardization of telecommunications systems
 - III.A.2. Development surveys for upgrading of information and communications base
 - III.A.3. Survey research for long-term encouragement of communications administration
- III.B. Advancement of telecommunications projects
 - III.B.1. Survey research on proper nature of telecommunications projects of the 1990's
 - III.B.2. Survey research on near-distance telephone system
 - III.B.3. Survey research on numbering plans
 - III.B.4. Survey research on telecommunications system safety and reliability
 - III.B.5. Survey research on assuring compatibility of functions in combined telecommunications networks
- III.C. Encouraging use and upgrading of electromagnetic spectrum
 - III.C.1. Survey research for effective use of the electromagnetic spectrum
 - III.C.2. Survey research on new communications systems and preparing an environment for their use
- III.D. Encouraging improvement of satellite communications use
 - III.D.1. Survey research for promotion of space communications measures
 - III.D.2. Survey research on policies for preparation of space infrastructure using the electromagnetic spectrum

Taxation

- III.A. Assistance to telecommunications projects
 - III.A.1. Expansion and expansion of special measures on property taxes

- III.A.2. Expansion of range of non-application of enterprise taxes
- III.A.3. Tax assistance measures for construction of next-generation communications networks
- III.A.4. Tax assistance measures regarding data communications systems
- III.A.5. Tax assistance measures regarding advanced network facilities, including ISDN
- III.A.6. Special measures on period for carrying over losses
- III.A.7. Elimination of time limit on application of special exemption on transfer taxes in connection with land for telephone exchanges, etc.

- III.B. Expansion of taxes to promote effective use of the electromagnetic spectrum (including additions to facilities covered)

- III.C. Extension of special depreciation in connection with underground placement of telephone cables

Fiscal investment and loans

- III.A.1. Encouraging preparation of trunk communications network for type I telecommunications enterprises
- III.A.2. Preparation of telecommunications foundation, including type II telecommunications enterprises and broadcast enterprises
- III.A.3. Encouraging upgraded telecommunications use, including effective use of frequencies
- III.A.4. Encouraging systemization of information processing and communications
- III.A.5. Assistance for construction of next-generation communications networks
- III.A.6. Joint communications and broadcasting development projects
- IV. Contributing to the Formation of a New International Community

Budget items

- IV.A. Enhancement of international broadcasting
 - IV.A.1. Implementation of international broadcasting
 - IV.A.2. Survey on improved reception of international broadcasting
- IV.B. Encouraging international coordination
 - IV.B.1. Survey research on international communications policy in the fields of information and communications
 - IV.B.2. Survey research for elimination of communications friction

IV.C. Encouraging international cooperation

IV.C.1. Encouraging technical cooperation related to overseas communications

IV.C.2. Basic survey on international cooperation in the field of telecommunications

IV.C.3. Contribution to the ITU Telecommunications Development Center

IV.C.4. Encouraging projects to promote exchanges of broadcast programming

Taxation

IV.A. Tax assistance measures to promote the international exchange of broadcast programming

IV.B. Extension of special property tax measures for assets used in international broadcasting

Interest-free lending

IV.A. Projects to prepare Teleports (national livelihood facilities)

Fiscal investment and loans

IV.A.1. Projects to prepare Teleports (national livelihood facilities)

IV.A.2. Promotion of communications satellite and communications equipment imports

IV.A.3. Promotion of overseas projects of telecommunications operators

V. Development of Technology to Build a Bright Future

Budget items

V.A. R&D on basic and advanced technology

V.A.1. Encouraging R&D on the telecommunications frontier

V.B. R&D on space communications technology

V.B.1. Development of R&D satellites in the field of communications and broadcasting

V.B.2. R&D on aviation and marine satellite technology

V.B.3. R&D on intersatellite communications technology

V.B.4. R&D on technology for high-precision measurement of space and time, using electromagnetic radiation from space

V.B.5. Experimental research on the Communications Satellite No. 3 (CS-3)

V.B.6. R&D on space-based weather reporting systems

V.B.7. R&D on communications technology using small satellites

V.C. R&D on measurement of the global environment

V.C.1. Research on dual-frequency Doppler radars rainfall observation from space

V.C.2. R&D on measurement of the global environment using active sensors in the optical realm

V.C.3. R&D on measurement of the global environment using electromagnetic waves in the shortwave and millimeter wave bands

V.C.4. R&D on construction of reporting networks for measurement of the global environment

V.D. Development of technology using the electromagnetic spectrum

V.D.1. Development of frequency resources

V.D.2. R&D on stratospheric radio relay systems

Taxation

V.A. Tax assistance measures to encourage R&D in the telecommunications field

Fiscal investment and loans

V.A.1. Encouraging basic information and communications technology making use of the Key Technology Center

V.A.2. Encouraging new R&D in the fields of communications and broadcasting